SURGERY, GYNECOLOGY AND OBSTETRICS

AN INTERNATIONAL MAGAZINE, PUBLISHED MONTHLY

VOLUME L FEBRUARY, 1930 NUMBER 2

THE MECHANISM OF OBSTRUCTIVE PULMONARY ATELECTASIS[1]

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ACQUIRED massive pulmonary atelectasis may be either compressive or obstructive. The relation of compression to an airless state of the lung, such as occurs in large intrapleural accumulations of fluid or air, extreme distortion of the thoracic cage, tumors, etc., has long been understood; but only recently has definite proof of the causal relation of bronchial obstruction to atelectasis been furnished by direct observation in man and reproduction in animals. Other causes than these have been suggested and may possibly account for some cases.

We were led recently to question the bronchial obstruction theory, as the result of seeing several dogs with total stenosis of a bronchus fail to develop atelectasis. We then repeated the experiments of others in animal reproduction, and did not secure their results. It was apparent that factors, unknown to us and essential to atelectasis formation, must have been different in our experiments. Further analysis of the mechanism involved was undertaken to determine these factors, and the results are presented here.

ETIOLOGICAL HYPOTHESES

As introduction, a brief review of the various etiological hypotheses for massive atelectasis is necessary. Complete presentations (8, 9, 18) and exhaustive bibliography (4) are obtainable elsewhere. The literature reveals the following etiological hypotheses:

1. *Decreased respiratory force.* Pasteur (26 and 27) found "massive collapse" of the lung in cases of postdiphtheritic paralysis of the diaphragm, and he attributed the airless state to reduction in depth of respiration. The mechanism was not more precisely described than to suggest that the lower lobes not employed in respiration spontaneously lost their air content.

Likewise, Bradford, in discussing the occurrence of massive atelectasis in wounds of the chest wall, considered it secondary to the immobilization and retraction which took place on that side of the chest. The immobilization was thought to be the result of reflex spasm of respiratory muscles.

2. *Disturbance of pulmonary circulation.* Gwyn's analysis of 18 cases of massive atelectasis left the question of etiology obscure, and he suggested the possibility of a vasomotor disturbance of the lung. The mode of its origin and action he did not attempt to explain.

3. *Bronchial obstruction.* Massive atelectasis has been seen frequently in association with inflammatory conditions of the lungs, and the likelihood of its following obstruction of the bronchi by inflammatory exudates has received much attention. Thus, Bartels described the condition in the pulmonary complications of measles. Postoperative collapse of the lung was attributed by Schrimger to bronchial irritation, local spastic contraction,

[1] This work has been conducted under a grant from the Douglas Smith Foundation for Medical Research of the University of Chicago.

and plugging of the narrowed lumen with mucus. Lord recognized it in various types of suppurative disease of the lower respiratory tract.

4. *Combined factors.* The most generally accepted hypothesis includes both bronchial block and decreased respiratory force (6, 7, 12, 16, 19, 20, 21, 22, 24). For instance, Jackson and Lee express their conception of the process leading to massive atelectasis in quoting Elliot and Dingley, "Consequent to immobilization of the thoracic wall and diaphragm, irrespective of its cause, secretion collects in the bronchioles and even in the larger bronchi, sufficient to prevent the egress of air, and leads to a gradual absorption of the alveolar air by the pulmonary circulation and ultimate collapse and airlessness of the lung tissue." A somewhat different mechanism is suggested by others (8, 13, 14, 32), who suppose the obstructing plug to have a ball-valve action in the tapering lumen of the bronchus, permitting air to escape from the lung in expiration and not allowing it to be inspired.

Bronchial block plus vasomotor disturbances are believed by Scott and Cutler (30, 31) to explain atelectasis, but these authors offer no detail as to mode of action.

EXPERIMENTAL REPRODUCTION

Section of the phrenic nerves in animals has resulted in pulmonary atelectasis in the hands of a few (7, 26, 29), but this has not been regularly the case. For example, Alexander not only divided one phrenic but also all intercostal nerves and the external respiratory nerve on one side in dogs and in man without causing massive atelectasis of the underlying lung. The operation of phrenicotomy as routinely performed is not followed by this condition.

The researches of Lichtheim, in 1878, are frequently referred to in support of the bronchial block theory. He occluded the bronchi of rabbits with foreign bodies and by ligature, and found the affected lung lobes airless a few days later. The loss of air was presumed to be by blood stream absorption. Unfortunately, sterile technique was not employed in operating and such complications as pneumonia and compressive atelectasis from empyema and pneumothorax interfered with the validity of the conclusions.

Massive atelectasis has been obtained experimentally with uniformity by three groups of workers. Lee and his associates (21) plugged the bronchus of a dog with thick mucus obtained bronchoscopically from a patient with massive collapse of the lungs; in other dogs mucilage of gum acacia was used. Within a few hours thereafter, the heart and diaphragm appeared in the X-ray to be displaced toward the side of the plug. No necropsy proof of atelectasis was given. Coryllos and Birnbaum later blocked the bronchus with an inflated rubber balloon and obtained X-ray and necropsy evidence of massive atelectasis. Bronchoconstrictor effects were produced by Dixon and Brodie with drugs and vagal stimulation, and it was found that when respiration was quiet and the expiratory phase was lengthened, massive atelectasis resulted.

The experiments that follow deal with the mechanism of atelectasis formation after bronchial block; particularly as regards respiration, whether quiet or straining; bronchial obstruction, whether total or valvular; fate of pent up air; rate of development; and intrathoracic pressures.

EXPERIMENTS

The experiments were carried out under morphine and ether anæsthesia or with heavy doses of sodium barbital or morphine alone. Adult, medium-sized dogs (body weight, 13 to 15 kilograms) were employed, and care was taken to exclude those with pre-existing respiratory disease. The experiments were concluded by electrocution (17), to avoid agonal phenomena, and the lungs were examined both grossly and microscopically.

1. *Type of respiration.* In dogs, in which bronchial obstruction had been instituted, the effect of the type of respiration upon the formation of atelectasis was determined. Two types of respiration were contrasted, namely, quiet breathing of normal or shallow depth, and what may be termed straining, i.e., breathing in which there is interference with the discharge of air from the lungs to the extent of requiring muscular effort to effect it. Straining respiration occurred spontaneously

Fig. 1. Bronchial plug "Michelin mastic" after removal, a tightly fitting cast.

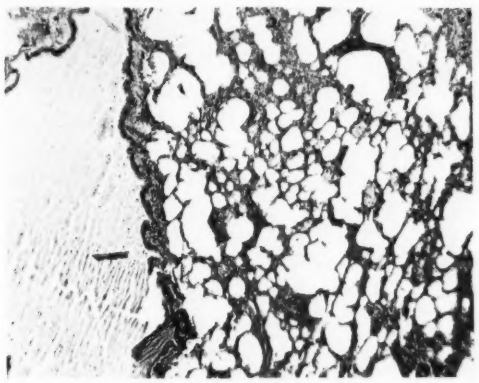


Fig. 2. Dog 122A. Photomicrograph. Air-containing lung after 45 days of bronchial obstruction and quiet respiration.

in some animals with whining, grunting, panting, and struggling, and in others it was induced by occluding the trachea partially with each expiration. The periods of time were varied.

The experiments were divided into four groups, depending upon the type of respiration, whether quiet or straining, and the type of bronchial obstruction, whether total or valvular. Typical protocols are given.

a. Quiet respiration with total bronchial obstruction occurred in 14 dogs.

Dog 774A showed quiet respiration with total obstruction of the middle, lower, and accessory lobe bronchi on the right under general anæsthesia. No atelectasis resulted.

By hypodermic injection, 0.060 grams of morphine and 0.004 grams of atropine were given. Ether anæsthesia was induced and tracheotomy done. Through the tracheotomy opening a solid plug of dumb-bell shape was inserted in the right primary bronchus. Positive pressure intratracheal anæsthesia was used (25), and the chest was opened on the right by intercostal incision, and a ligature was passed around the primary bronchus just proximal to the branch to the middle lobe. The lungs were then fully inflated and the ligature tied tightly, compressing the bronchial wall into the groove of the plug. The wound was then closed, with care to avoid pneumothorax. The respirations were maintained quiet and shallow by continuing deep ether anæsthesia. The dog was sacrificed 13½ hours later.

Autopsy showed the plug securely obstructing the bronchi of the right middle, lower, and accessory lobes. These lobes were fully air-containing and without trace of atelectasis.

Dog 455A showed quiet respiration with total obstruction of the right lower and accessory lobe bronchi under morphine narcosis. The dog was sacrificed 24 hours later. No atelectasis resulted.

Morphine, 0.166 grams, and atropine, 0.004 grams, were administered. With the dog in a profoundly somnolent state, a bronchoscope was passed and the bronchi of the right lower and accessory lobes were packed tightly with "Michelin mastic," which is a malleable, sticky rubber preparation commonly used to stop leaks in automobile tires. The bronchoscope was then removed and the dog allowed to lie quietly in morphine sleep for 24 hours. Then, a few minutes before sacrificing, 5 cubic centimeters of a watery solution of methylene blue was instilled into the bronchus proximal to the obstruction, to prove its effectiveness.

The autopsy showed the larger bronchi of the lower and accessory lobes tightly filled by a cast of the elastic medium (Fig. 1). The dye had not penetrated past this obstruction; indeed, the air in the lobes did not escape on their removal from the chest. These lobes were inflated to a normal degree and, except for ecchymotic patches secondary to trauma, could not be distinguished from the other lobes.

Dog 122A showed quiet respiration and total cicatricial stenosis of the right lower lobe bronchus. After 45 days the dog was sacrificed. No atelectasis resulted.

After the administration of 0.166 grams of morphine, a stick of silver nitrate was introduced bronchoscopically and a 1 centimeter length of the bronchus lying well within the lower lobe was cauterized. The dog was allowed to live under routine kennel care. For a few days it was quiet and without appetite, then became normal. No respiratory symptoms presented themselves. Sacrifice was made at the end of 45 days.

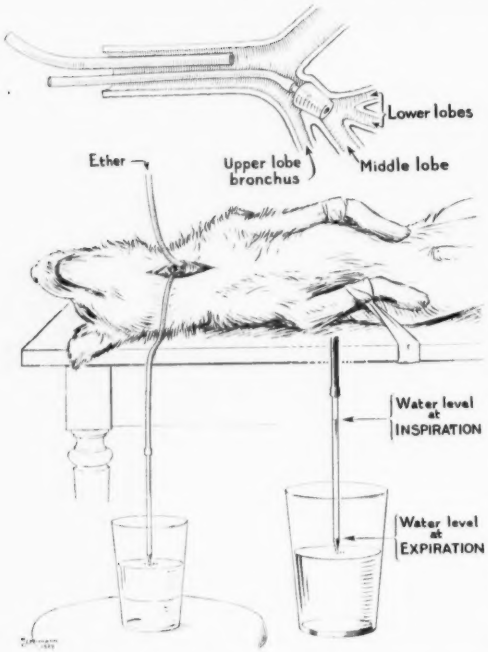


Fig. 3. Dog 482A. Method for water-valve bronchial obstruction. Above, Cannula inserted in right primary bronchus; below, water-valve apparatus set up; right behavior during quiet respiration.

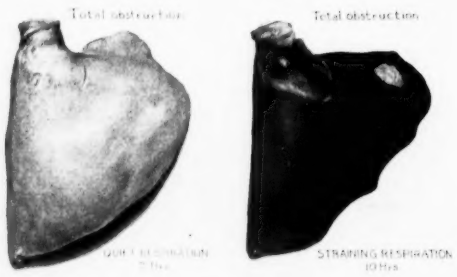


Fig. 4. Straining contrasted with quiet respiration as to atelectasis formation. At right, Dog 773A. Lower lobe. Total atelectasis after straining and bronchial obstruction. At left, Dog 803A. Lower lobe. Air-containing condition after quiet respiration and bronchial obstruction.

Autopsy showed that the lungs were normal in appearance except for fibrous adhesions between the right lower and accessory lobes. Section into the right lower lobe showed the medial division of the bronchus to be destroyed over a length of about 2 centimeters and replaced by a mass of firm necrotic tissue encapsulated in scar tissue. This caused a complete interruption of the bronchial lumen, and the bronchioles in the periphery were distended with viscid glassy mucus. The parenchyma supplied by this section of the bronchial tree was, however, not different in appearance from that of other parts of the same and other lobes. It was normally air-containing and floated in water. The vessels were intact. Microscopic examination of the parenchyma revealed bronchioles everywhere distended with mucus and alveoli inflated (Fig. 2).

The first, acute type of experiment was performed 7 times, the second subacute experiment 4 times, and the third chronic one 3 times.

b. Quiet respiration with valvular bronchial obstruction was instituted in 4 dogs.

Dog 482A showed quiet respiration with valvular obstruction of the right lower and accessory lobe bronchi under general anæsthesia. The dog was sacrificed 3½ hours later. No atelectasis was found. Morphine, 0.100 grams, and atropine, 0.001 grams, were given. Ether anæsthesia was used and tracheotomy done. A wooden cannula was wedged snugly into the right primary bronchus, and from this a rubber tube led out of the trachea. Attached to the tube was a glass cannula, and the tip of this was submerged in water. The anæsthesia was maintained by insufflation (Fig. 3). The dog was allowed to lie breathing quietly for 3½ hours and the glass cannula was observed in order to determine the behavior of the pent-up bronchial air. With each inspiration, the water was drawn up about 10 centimeters, and at expiration its meniscus was lowered again to the water level. These levels remained constant during the entire period. No air escaped.

The dog was sacrificed and autopsy showed the plug tightly lodged and cannulating the lower and accessory lobe bronchi. These lobes presented no atelectasis or deflation.

c. Straining respiration with total bronchial obstruction was seen in 14 dogs.

Dog 773A showed straining respiration with total obstruction of the right lower and accessory lobe bronchi under general anæsthesia. Ten hours later the dog was sacrificed and complete atelectasis of the obstructed lobes was found.

Morphine, 0.070 grams, and atropine, 0.001 grams, were given. Anæsthesia was induced by ether. After tracheotomy a solid dumb-bell shaped plug was inserted and ligated into the right primary bronchus, as in Dog 774A, obstructing the branches to the lower and accessory lobes. Resistance to expiration was instituted, as follows: A steady current of air laden with ether vapor sufficient to carry a light anæsthesia was insufflated into the open trachea, and the tracheal lumen was partially closed. The resistance thus created to expired air was not greater than to produce an intratracheal pressure of 3 millimeters of mercury, and since the dog is capable of exerting much higher pressures than this, the lungs did not suffer undue distention. Straining respira-

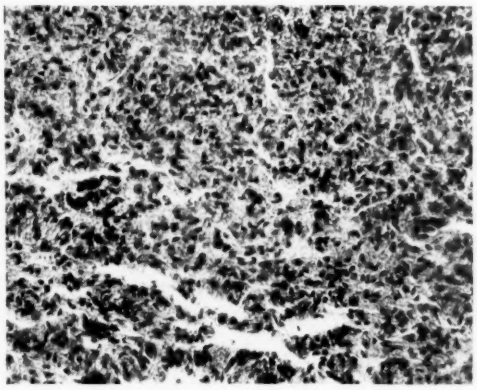


Fig. 5. Dog 773A. Photomicrograph of a section of an atelectatic lung after straining respiration and bronchial obstruction.

Fig. 6. Dog 647A. Lungs. Atelectasis of right lower lobe after straining respiration and valvular bronchial obstruction.

tion was thus carried on for 10 hours, until the dog was sacrificed.

At autopsy the plug was found firmly occluding the right lower and accessory lobes, and these were collapsed, deep purplish blue in color, non-crepitant, and of the consistency of muscle (Fig. 4). When detached and placed in water, they sank. Microscopic examination revealed a completely airless state of the parenchyma (Fig. 5). Other lung lobes were normal in appearance.

d. Straining respiration with valvular bronchial obstruction was produced in 19 dogs.

Dog 647A showed straining respiration with valvular obstruction of the right lower lobe bronchus under general anæsthesia. Five hours later the dog was sacrificed and complete atelectasis of the right lower lobe was found.

Sodium barbital, 4.2 grams, was intraperitoneally injected and produced light anæsthesia. Tracheotomy was done and a wooden cannula was inserted in the bronchus to the right lower lobe and connected to a water-valve, as in Dog 482A. Straining respiration was induced as in Dog 773A. Immediately with each expiration a stream of air bubbles escaped from the water-valve outlet and continued to do so for about 1 hour, after which no more appeared. The dog was sacrificed 5 hours later.

Autopsy showed the cannula firmly fixed in the bronchus of the right lower lobe, and that lobe was completely atelectatic, as in Dog 773A (Fig. 6).

The results of 36 experiments of the types illustrated above are collected in graphic form in Figure 7, contrasting the effects of quiet with straining respiration in the presence of bronchial obstruction. The periods of obstruction varied from 2 to 24 hours and the amounts of atelectasis from 0 to 100 per cent of the affected lung parenchyma. Quiet respiration was obtained in 10 dogs and straining in 22 dogs. The former developed no atelectasis or any degree of lung deflation, and the circles, which represent them, are situated over "0" at the left on the scale of atelectasis; while the latter uniformly had atelectasis from 12 to 100 per cent, as represented by the dots distributed to the right. Four circles contain numerals and refer to experiments intended for quiet breathing but in which the animals panted or accumulated mucus obstruction in the trachea. Here straining occurred spontaneously to slight extents and corresponding amounts of atelectasis were found.

2. *Type of bronchial obstruction.* The effect of obstruction of the bronchus by a heavy mucilage of gum acacia, according to the experiments of Lee *et al* (21), was investigated, and it was found that atelectasis resulted only when the respirations were straining in type. Thus, 2 dogs with quiet respiration, obstructed for 12 hours, showed no deflation of the affected lobes; and 2 others with straining breathing and the same sort of obstruction developed atelectasis.

3. *Fate of air pent up in the lung.* The experiments serve to indicate the manner of disappearance of air from the lung during the development of obstructive atelectasis, (*a*) in total and (*b*) in valvular bronchial obstruction.

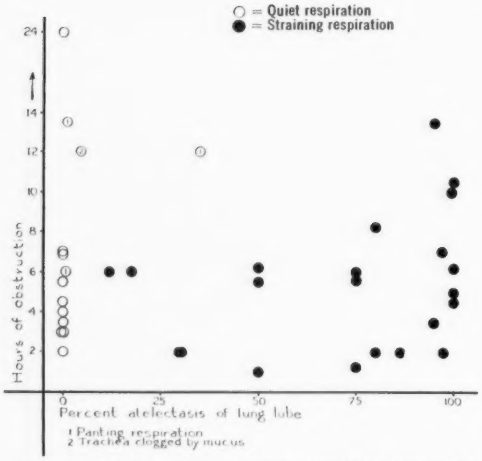

○ = Quiet respiration
● = Straining respiration
Hours of obstruction
Percent atelectasis of lung lobe
1 Panting respiration
2 Trachea clogged by mucus

Fig. 7. Chart of 36 experiments. Straining contrasted with quiet respiration as to atelectasis formation. Total or valve obstruction.

a. Total bronchial obstruction and straining respiration was observed in 4 dogs.

Dog 769A, with total obstruction of right lower and accessory lobe bronchi and ligature of the blood supply to the accessory lobe, showed straining respiration under general anæsthesia. After 6 hours, the dog was sacrificed. The results were atelectasis of the lower lobe and failure of atelectasis of the accessory lobe.

Morphine, 0.100 grams, and atropine, 0.001 grams, were given and ether anæsthesia induced. A solid dumb-bell shaped plug was inserted and ligated into the right primary bronchus, as in Dog 774A, obstructing the branches to the lower and accessory lobes. The bronchus and vessels to the accessory lobe were separately ligated, care being exercised that the lobe was left inflated to the normal degree. Straining respiration was then instituted for 6 hours, after which the dog was sacrificed.

At autopsy the bronchial plug and ligatures were intact. The right lower lobe was deflated and largely atelectatic. The accessory lobe was normally air-containing and differed in appearance from unobstructed lobes only in having a somewhat cyanotic hue (Fig. 8).

b. Valvular and total bronchial obstruction and straining respiration were produced by 2 dogs.

Dog 839A, with valvular obstruction of right lower and accessory lobe bronchi, total obstruction of the middle lobe bronchus, and ligature of the blood supply to the lower lobe, showed straining respiration under general anæsthesia. Escaping air was measured. After 10½ hours the dog was sacrificed. The result was atelectasis of the middle, lower, and accessory lobes.

Morphine, 0.100 grams, and atropine, 0.001 grams, were given and ether was used to induce anæsthesia.

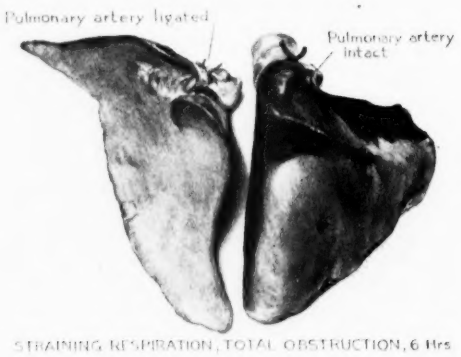


Fig. 8. Dog 769A. Rôle of pulmonary circulation in atelectasis formation. Right, lower lobe, vessels intact. Partial atelectasis after bronchial obstruction and straining. Left, accessory lobe, vessels ligated. Air-containing condition after same.

Tracheotomy was done. A wooden cannula was inserted in the right primary bronchus and connected to a water valve, after ligating the vessels to the right lower lobe. The mouth of an inverted Erlenmeyer flask filled with water was submerged over the water valve outlet, to receive air that might escape. Straining respiration was then instituted. Within 10 minutes, 125 cubic centimeters of air collected in the flask; at the end of 1 hour, 150 cubic centimeters of air had collected. No more appeared. The dog was sacrificed 10½ hours later.

Autopsy showed the bronchial cannula securely in place, communicating freely with the lower and accessory lobes. The sides of the cannula obstructed completely the opening to the middle lobe bronchus. The lower lobe was collapsed and showed scattered areas of atelectasis, the accessory lobe was totally atelectatic, and the middle lobe was almost totally atelectatic (Fig. 9).

4. *Rate of development.* The rate of formation of obstructive pulmonary atelectasis was studied in relation to the type of obstruction, total or valvular. The amount of deflation of the obstructed lung was estimated in four ways, viz., approximate estimation by observation of the proportion of atelectatic to air-containing parenchyma, measurement by submersion in water of the volume of the lung in proportion to its volume when re-inflated, measurement of the volume of air given off through a valve obstruction, and determination by X-ray photographs of the degree of mediastinal shift.

Dog 841A, with total obstruction of accessory lobe bronchus and valvular obstruction of lower lobe

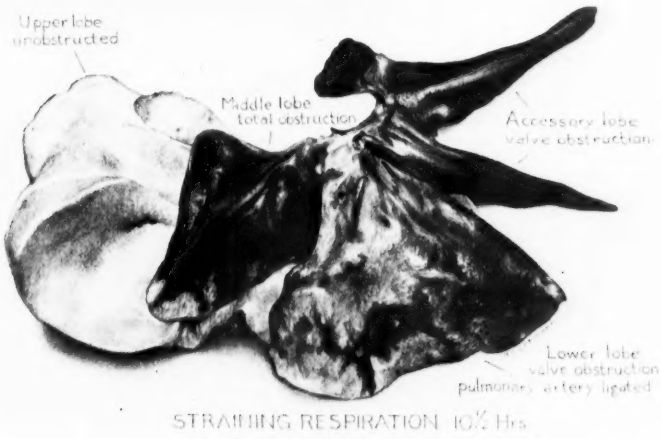


Fig. 9. Dog 839A. Right lung. Rôle of pulmonary circulation in atelectasis formation. Right above, accessory lobe, vessels intact. Complete atelectasis after valvular obstruction and straining. Right below, lower lobe, vessels ligated. Partial atelectasis after valvular obstruction. Center, middle lobe, vessels intact. Complete atelectasis after total obstruction. Left, upper lobe, vessels intact. Air-containing condition without bronchial obstruction.

bronchus, showed straining respiration under general anæsthesia. After sacrifice of the dog 2 hours later, the findings were: accessory lobe normally inflated; lower lobe collapsed to 25 per cent of normal size and 95 per cent atelectatic.

Morphine, 0.033 grams, and atropine, 0.001 grams, were given. Ether anæsthesia was used and tracheotomy was done. The bronchi of the accessory lobe were plugged with "Michelin mastic" as in Dog 455A, and a dumb-bell shaped cannula was tied into the bronchus of the lower lobe. The cannula was connected with a water valve and straining respiration was carried on for 2 hours. Air escaped from the valve with each expiration during the first ½ hour. The dog was then sacrificed.

At autopsy the plugs were found firmly in place. The accessory lobe was normally air-containing. The lower lobe was shrunken to 25 per cent of normal size and 95 per cent of the parenchyma was atelectatic (Fig. 10).

Dog 842A was used for a repetition of the preceding experiment with a shorter period of obstruction. After 40 minutes the dog was sacrificed. The results were: accessory lobe (total obstruction) normally inflated; lower lobe (valvular obstruction) collapsed to 25 per cent of normal size and without atelectasis.

Analysis of the results of 20 experiments of this sort shows the rate of atelectasis formation to be quite variable in different individuals and to depend upon the amount of exertion in the straining respiration and upon the type of obstruction. Thus, total obstruction rarely caused more than 25 per cent atelectasis in 6 hours, whereas valvular plugs brought about high grades of the condition within 2 hours. In those dogs which strained forcefully and had efficient valvular plugs, collapse of the affected parts of the lung took place within a few minutes, although actual atelectasis developed later. For example:

Dog 843A, with valvular obstruction of bronchus of entire right lung showed straining respiration under general anæsthesia. Measurement of escaping air was made and serial X-ray photographs were taken. The results showed that 500 cubic centimeters of air escaped and there was marked mediastinal shift in 2 minutes; the right lung was reduced to 20 per cent normal size and was 25 per cent atelectatic.

Morphine, 0.016 grams, and atropine, 0.001 grams, were given. Ether anæsthesia was induced. After tracheotomy a cannula was tied into the right primary bronchus to include all branches and was connected with a water-valve and collecting flask as in Dog 839A. The animal was then placed under the X-ray tube and upon a plate-changing tunnel and was arranged in true dorsal recumbent position. An exposure was made (Fig. 11, a) and then straining respiration was instituted. Repeated exposures were taken at intervals thereafter, care being taken that the position of the animal was not altered. The air that escaped was measured and symptoms noted.

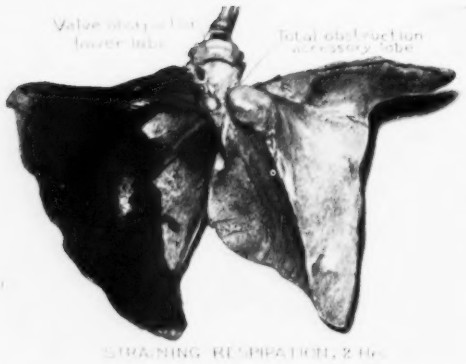


Fig. 10. Dog 841A. Total contrasted with valvular obstruction as to rate of atelectasis formation. Straining respiration for 2 hours. Right, accessory lobe. Air containing condition after total obstruction. Left, lower lobe. Atelectasis after valvular obstruction.

In 2 minutes, 500 cubic centimeters of air had escaped and the mediastinum had shifted markedly to the right (Fig. 11, b).

At the end of 15 minutes, 25 cubic centimeters more of air had escaped and there was slightly greater mediastinal displacement. The right side of the chest was noticeably depressed and motionless. There was no distortion of the diaphragm, nor any dyspnœa.

After 58 minutes, no more air was given off. The left lung field appeared denser. X-ray pictures taken at the end of 83 minutes and 120 minutes showed no change (Fig. 11, c). The dog was sacrificed.

Autopsy showed the heart lying entirely in the left side of the chest and the diaphragm drawn up symmetrically to a level distinctly higher than normal. The entire left lung was collapsed to 20 per cent of its normal size and presented extensive areas of atelectasis. The right lung was enormously overdistended and emphysematous (Fig. 12).

5. *Pattern of development.* The specimens removed at various stages in the development of atelectasis in the above experiments presented a consistent pattern of origin and spread of alveolar collapse. The first alteration from the normal was uniform deflation, as occurs with simple pneumothorax collapse. The lung was reduced in size but crepitant and without change in appearance. Atelectasis, or complete alveolar collapse, then began in the hilus region as a sharply defined, irregular, purplish blue area which was depressed, non-crepitant, and of the consistency of muscle tissue. The atelectasis gradually extended toward the periphery in irregular, finely demarcated outline. The peripheral margins were the last to become involved. This centrifugal progression of atelectasis is illustrated by Figure 13. It was the same whether the obstruction was total or valvular.

6. *Intrathoracic pressures.* The intrapleural and intrabronchial pressures were investigated during the development of obstructive atelectasis. The results of the following experiment were typical of 3 that were performed.

Dog 645A, with valvular obstruction of right lower and accessory lobe bronchi, showed straining respiration under general anæsthesia. Pressures within the pleura and the obstructed bronchi were measured. At the end of 70 minutes, the dog was sacrificed. The findings were atelectasis of lower and accessory lobes and depression of intrabronchial and intrapleural pressures.

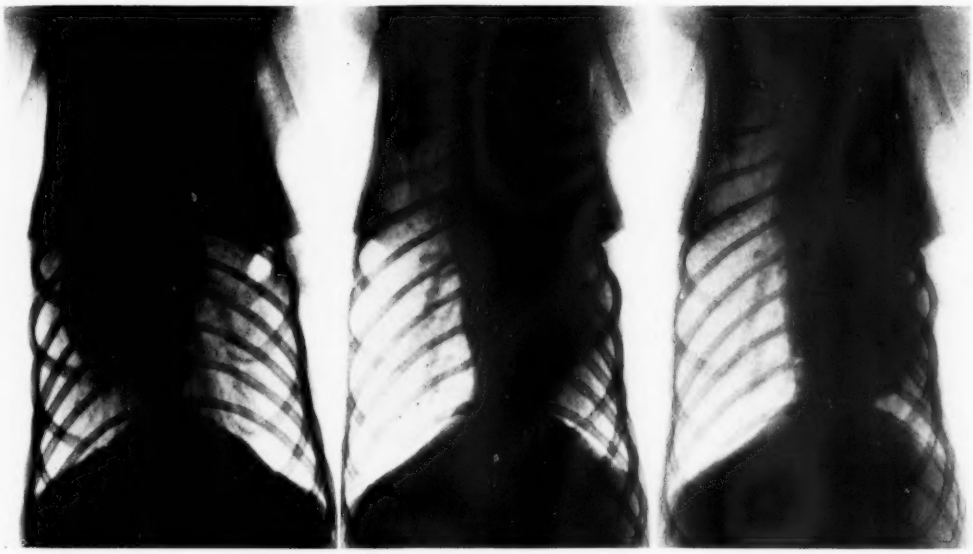
Morphine, 0.083 grams, and atropine, 0.001 grams, were administered. Ether anæsthesia was induced. After tracheotomy, a cannula was inserted in the right primary bronchus and connected with a water valve. A side tube from this led to a water manometer, to indicate the pressures within the obstructed bronchial tree. A pleural cannula was inserted and connected with a second water manometer. Periodic readings were taken from each manometer at inspiration and expiration before and after the start of straining respiration. The dog was sacrificed at the end of 70 minutes.

The readings are plotted in Figure 14. The curves represent the inspiratory pressures—the upper, the intrabronchial; and the lower, the intrapleural. The perpendicular lines indicate the expiratory excursions. With the onset of straining, air began to escape from the water-valve and the intrapleural pressures began to fall from the initial level of −160 and −162 millimeters of water and reached −290 and −342 millimeters of water in 53 minutes, when air ceased to escape. There was then a slight rise before termination of the experiment. The intrabronchial pressures behaved differently, for, starting at −10 and −80 millimeters of water, the expiratory pressure diverged from the inspiratory. The latter fell in a manner similar to the intrapleural pressures, although more rapidly, and the former rose to atmospheric pressure. At the end of 53 minutes each tended to return to its former level.

At autopsy the cannula was found firmly in place in the bronchus to the lower and accessory lobes, and these lobes were atelectatic.

DISCUSSION

Diminished respiratory excursion with retraction of one side of the chest is seen quite strikingly in association with massive atelectasis of the underlying lung and, whatever the interpretation of this has been (diphtheritic



a. b. c.

Fig. 11. Dog 843A. Serial roentgenograms. Valvular obstruction and rate of atelectasis formation. a, Status before straining respiration; b, after 2 minutes of straining; c, after 2 hours of straining.

paralysis, reflex spasm from painful injuries, pull of the collapsed lung, etc.), reduced force of breathing has become generally accepted as essential to the formation of atelectasis. Thus, quiet breathing is believed to promote the accumulation of excessive bronchial secretions in dependent parts and, after bronchial obstruction has occurred, to favor absorption of the imprisoned air by the blood stream. From this hypothesis has arisen the practice of stimulating the respirations for the prevention and treatment of atelectasis. Deep breathing is encouraged by suggestion and eliminating sedatives or is enforced by carbon dioxide inhalations, and coughing is induced by slapping the chest and rolling the patient from side to side. Under these circumstances more or less relief has been reported.

That diminished force of respiration is secondary rather than primary to atelectasis one is convinced of by observing the breathing movements of a dog with massive obstructive atelectasis of one lung. The affected side of the chest, here as in man, is seen to be drawn in and comparatively immobile; but symmetry of respiratory excursions returns immediately

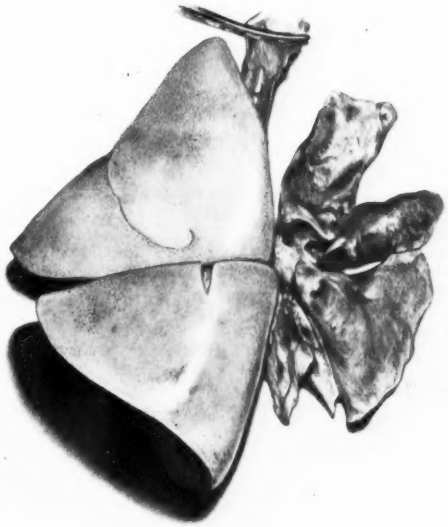


Fig. 12. Dog 843A. Lungs. Result of valvular obstruction and 2 hours of straining. Right lung collapsed and largely atelectatic (Fig. 11).

Fig. 13. Dog 805A. Pattern of atelectasis formation. Left, middle lobe. Beginning atelectasis. Center, lower lobe. Advancing atelectasis. Right, accessory lobe. Total atelectasis.

after pneumothorax is induced and the chest wall released from the pull of the collapsed lung beneath.

As to the prevention and treatment of atelectasis, we are not at all in a position to dictate, for these experiments have dealt with occlusion of the normal lung and permit no certain predictions as to the behavior of the inflamed or otherwise abnormal lung with bronchial obstruction, such as is presented usually in clinical cases of massive atelectasis. Indeed, further study in hand is already indicating that the mechanism of atelectasis formation in the pathological lung is more complex than hitherto represented. But we are able positively to say as to the normal lung that any mode of breathing that entails expiratory effort against resistance encourages absorption of pent up pulmonary air. The work of others (2) has shown that cough aids in eliminating fluids which lie in the larynx, trachea, and largest bronchi only and drives still farther into the periphery those lying more deeply. Viscid material like mucus contained in the lumen of a bronchus tends to adhere to its walls during both phases of respiration and, after escape of the tidal air, to move back and forth rather than to allow air to pass. It is, therefore, misleading to apply to the case of obstruction by secretions the teachings of Jackson and his school as to the behavior of rigid foreign bodies in the bronchi, for the latter do not conform themselves to luminal alterations unless impacted and may permit air to be inspired with the inspiratory enlargement of the bronchus. We feel that the present state of our knowledge of the dynamics of bronchial obstruction and of the circumstances attending the absorption of captive pulmonary air under clinical conditions is too meagre to permit judgment even as to the safety of such active measures as have been used for intervention in atelectasis. It may well be, for instance, that coughing and straining promote instead of prevent lung collapse in the inflamed as well as the normal organ; and precisely how hyperpnœa may act to reinflate a lung sector whose bronchus is clogged with mucus is yet to be explained. Bronchoscopic aspiration of mucus in this condition should be reserved for those who are extraordinarily skilled in the technique and certain of being able to avoid additional irritation to the bronchial mucosa, else the operation may have to be repeated. Certain passive measures in prevention and treatment are probably advantageous, and these permit gravity to assist ciliary action in removing secretions. "Wet" patients should be placed in a partial Trendelenburg position and turned occasionally from side to side. If lung collapse has already occurred, the affected side should remain uppermost.

It is a curious circumstance that air which is imprisoned within the normal lung under conditions of quiet respirations remains with-

out absorption for a long time, if, indeed, it is ever absorbed, whereas air introduced into the neighboring pleural cavity or into the tissue spaces elsewhere tends quickly to disappear. Perhaps the query is more pertinent as to why air, and especially the nitrogenous part of it, at any point should be absorbed; and this may be elucidated by determining what factor of straining respiration it is which accounts for air removal from the occluded lung.

Those experiments designed to test the part played by the blood stream in atelectasis formation must be guarded as to interpretation. In ligating the vessels the nerves to the lung may also have been injured, and the failure of air absorption under these circumstances (and with bronchial plugging and straining breathing) may have been due to either or both of the effects. The part played by the nerve supply is now under investigation.

Experiments with valvular bronchial obstruction have been included in the presentation because of the striking part that this form of block had in discarding air from the lung during straining respiration and because the means were thereby afforded of studying the pressures within the occluded bronchus. But we wish most emphatically to prevent the impression that these experiments were supposed to portray the circumstances of spontaneous bronchial obstruction in man, since we doubt that material of any sort is capable of acting within the bronchus as a valve to permit residual air to escape from the lung. This matter also is receiving further consideration experimentally.

Reference to Figure 14 shows that after formation of atelectasis the pressures within the occluded bronchus and the pleural cavity are considerably depressed. Lowered intrapleural pressure in this condition was first noted by Elkin and is the result of lung shrinkage within resisting parietes. Estimation of the intrapleural pressure should be a simple and reliable clinical diagnostic procedure in massive atelectasis.

Attention should be called to the fact that atelectasis spreads in a lung lobe from the hilus toward the periphery and not in the opposite direction, as commonly supposed (9).

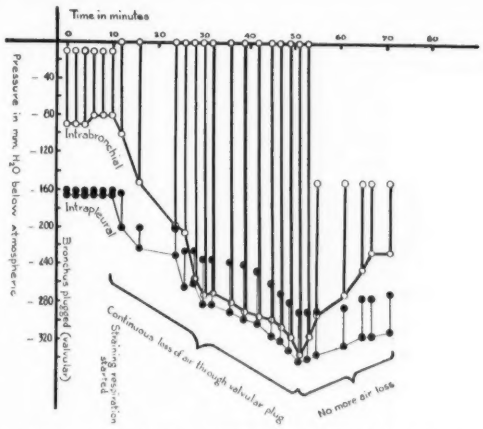


Fig. 14. Dog 645A. Chart of intrabronchial and intrapleural pressures (expiratory and inspiratory) during development of obstructive atelectasis.

The latter idea has arisen from finding at autopsy patches of airless parenchyma along the lung margins and interpreting them to be the early stages of massive atelectasis. Such lesions are probably due to obstruction of peripheral bronchioles.

CONCLUSIONS

The conclusions may be summarized as follows:

1. Quiet or suppressed respiration with bronchial obstruction does not lead to pulmonary atelectasis in the normal lung.
2. Straining respiration is essential to the production of obstructive pulmonary atelectasis in the normal lung.
3. Valvular obstruction produces atelectasis much more rapidly than does total obstruction, but there is no evidence that valvular obstruction occurs spontaneously in man.
4. Pent up bronchial air is probably lost from the lung by blood stream absorption.
5. Obstructive atelectasis develops centrifugally through the lung parenchyma.
6. Decreased intrapleural and intrabronchial pressures occur characteristically in obstructive pulmonary atelectasis.

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HÆMANGIOMA OF TENDON AND TENDON SHEATH

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IT is the purpose of this report to direct attention to an interesting group of vascular neoplasms of tendons and tendon sheaths. Angiomata, located in unusual places, are not infrequently seen but are seldom correctly diagnosed. Those deep angiomata found in muscle, bone, and nerve have been sporadically recorded in the literature. Sato (1) reported angiomatous involvement of the median nerve. Stewart and Bettin recounted similar disease of the sciatic nerve and its branches. Mondor and Huet published a comprehensive survey of 186 cases of angiomata of muscles. Hitzrot collected 26 cases of angiomata of bone. Osgood wrote of a case of angioma of the knee joint, in which the infrapatellar fat pad was the seat of disease.

However, angiomata originating in tendons and tendon sheaths are possibly the rarest of these types, and, consequently, they are not frequently considered in the diagnosis of tendon tumors. A review of the literature reveals but 10 cases. In 1913 Weil reported 6 cases, including those of Delagenière, Richet, Partsch, and Gottstein. Janik, Chauvin and Roux, and Schwartz have each described a case with definite angiectatic tendencies. Faldini has recently reported a case of a lymph angioendothelioma arising from the tendon sheaths on the medial aspect of the ankle, with definite metastatic tendency.

To these cases we wish to add 6 hitherto unpublished ones. We are concerned with angiomata, arising primarily from tendons and their sheaths, whose presence gives rise to a question of diagnosis—not with the multiple discrete or diffuse type of angioma in which tendons are only incidentally involved (Cruveilhier, Barling).

CASE 1. C. E. D., admitted to the clinic January 16, 1924, complained of pain which began in the left knee 6 years earlier. More or less steady pain had been present about an inch above the knee cap. The patient limped when the pain was severe. No history of trauma existed except that of a mild injury to the knee 2 years prior to the onset of the symptoms described. No constitutional symptoms were discovered. The general examination revealed nothing unusual. The local examination showed an extremely sensitive area 1¼ inches above the upper edge of the patella, at the outer border of the quadriceps tendon. When the muscle was contracted, the sensitive spot could be found; when the muscle was relaxed, one could palpate under the edge of the tendon and elicit pain. There was ¾ inch atrophy of the thigh. The reflexes were normal. The X-ray showed several free bodies in the knee joint. All laboratory tests were negative. The preoperative diagnosis was traumatic myositis.

The patient was operated upon by Dr. Steindler on February 14, 1924. Just external to the joint synovia and arising from the quadriceps tendon was a red-blue, cirsoid-appearing mass. It did not pulsate. On being cut into, it bled profusely. The tumor was resected with the adjacent tissues, since it had infiltrated the immediately surrounding muscles and tendons. Not all of the quadriceps tendon could be resected. A compression bandage was applied. The wound healed well and 6 months later no recurrence had been noted. In December, 1928, 3½ years later, the patient was again operated upon because of persistent aching in the region of the first operation. No evidence of recurrence could be made out. Scar tissue binding the quadriceps tendon to the femur was resected. Relief was obtained by this procedure. Incidentally, a port wine hæmangioma 2½ inches square was found over the nape of the neck. He stated it had been present since infancy and enlarged "with the full of the moon." Seen again in March, 1929, he was completely free from symptoms. He lacked 15 degrees of having full flexion of the knee.

The pathological report showed that the gross specimen consisted of a formless mass of tissue measuring 5 by 2 by 3 centimeters. It was made up of numerous spaces lined with a shiny membrane. A tab of fatty tissue was attached to it. Only one section of the tumor was made. It showed very large spaces lined by endothelium. These spaces anastomosed and were often separated by thin septa of fibrous tissue. Beneath the spaces was a dense fibrous tissue. The pathological diagnosis was cavernous angioma.

CASE 2. D. P., a girl aged 10 years, was admitted August 10, 1925, with a growth on the left little finger and on the left wrist, which had been present since birth, and which had continued to increase in size, commensurate with her own growth. There was no pain. At times during illnesses, as when she had measles, the hand and wrist became flexed and a clonic tremor appeared. When the finger was pricked, the blood spurted much higher than when

Fig. 1. Cavernous hæmangioma. (4 millimeters Leitz objective.)

another finger was punctured and bleeding was harder to stop. When the finger was elevated, it became narrower and almost normal; when depressed, it became full and pulsated. The finger had always been bluish. The mother stated that the tumor in the wrist varied in size and often caused pain.

Physical examination was negative except for the local condition. A soft, subcutaneous, non-tender, fluctuating mass was present on the palmar aspect of the distal phalanx of the little finger. Both the nail and the skin covering the entire distal phalanx were cyanotic. The end of the finger was the size of a hickory nut. In the left wrist, just radial to the flexor tendons, was a soft fluctuating mass about 3 centimeters in diameter. It was not tender and did not pulsate.

The patient was operated upon by Dr. Peterson, August 13, 1925. Under ether anæsthesia, boiling saline was injected into different portions of the finger growth. An incision was made over the mass in the wrist and, on cutting through the vaginal fascia, a blue mass was found, adherent to the sheath of the flexor tendons. (The exact tendons are not mentioned.) The tumor was carefully dissected, and it was necessary to remove part of the tendon sheath. The tumor involved the sheath and merely enveloped the unaffected tendons. Closure was in layers.

The pathological report was as follows: the specimen consisted of a small, irregularly shaped piece of tissue, encapsulated. Many red areas were visible. Microscopically, the tumor was seen to consist of rather dense fibrous tissue surrounding many large spaces. These spaces contained blood and all were lined by a single layer of endothelium. The diagnosis was cavernous hæmangioma.

The patient returned for re-examination on June 7, 1926. About 2 years earlier she had noticed that a swelling was beginning to appear in the upper portion of the anteromesial aspect of the forearm. This swelling had been gradually enlarging and spreading. Occasionally, the elbow joint seemed momentarily fixed in flexion. During the last 6 months she had noticed a swelling just medial to the operative scar of last year. Sharp, cutting pains had been present in the region of the old scar. Examination at this time showed the old scar on the anterolateral portion of the forearm. Along the anteromesial aspect of the entire forearm, there was a soft fluctuant swelling, more or less divided into halves. The lower half was very soft, not discolored, and not attached to the skin. The upper half showed more diffuse changes. The tumor blended with the tissues in the antecubital fossa. No inflammatory characteristics were discernible. On the little finger mesially was a bluish soft swelling.

The patient was re-operated upon by Dr. A. Kolodny, on June 14, 1926. An incision 4 inches long was made along the swelling in the upper third of the forearm. The tumor was beneath the vaginal fascia, embedded in the muscle tissue. It was extremely diffuse and infiltrating. A partial resection, requiring abundant ligations, was done. Complete removal of the angiomatous tissue would have necessitated complete resection of the forearm muscles. The tumor apparently had spread upward from the distal portion of the forearm, where the angiomatous mass was found to envelop all the tendons on the flexor side of the forearm. At the wrist, another incision revealed a similar tumor infiltrating and surrounding the tendons. Portions of the tumor were removed. It was deemed inadvisable to go further, since it was very difficult to control the persistent oozing of blood from the seat of the tumor mass. The wounds were closed with catgut and beeswax silk. A few small areas of infection prolonged healing. X-ray therapy was then started and continued to August 23, 1927, at which time no gross recurrence had been made out. The skin about the scars remained purplish and somewhat nodular in places. The finger was unchanged. The patient has not been seen since then.

The pathological report showed a gross specimen consisting of a small piece of reticulated tissue, which suggested a tumor of blood vessel origin. Two sections were made, both showing much striated muscle tissue and fat. Both sections showed that the tumor invaded muscle. The tumor tissue consisted of large spaces, lined with endothelial cells, and filled with red blood cells. In places, the tumor was replaced by a dense fibrous tissue. No mitotic figures were seen. The diagnosis was cavernous hæmangioma (Fig. 1).

Case 3. L. S. T., a negress aged 7 years, had been treated at this hospital for infantile paralysis for 4 years. During the last 6 months of that time the mother had noticed a lump on the outer side of the left leg, about 5 inches above the ankle. It occasioned

an increase in the limp when the child was up and about for unusual periods. No change in the size of the lump had been observed. Inspection of a 4-year series of photographs showed the presence of this mass in each picture. It had apparently passed unnoticed by both patient and doctor. The relevant findings were these: on the lateral aspect of the left leg, in its lower third, was a small tumor, 5 by 4 by 4 centimeters, which, while not fluctuant, was soft and slightly mobile. It was deeper than the subcutaneous tissue, the skin above it appearing normal. The tumor did not seem to move with contraction of the peronei. No nævi were present and there were no other tumors. The tumor was thought to be a fibroma.

The patient was operated upon on May 20, 1928, by Dr. Burman. By a curved incision over the tumor, the vaginal fascia was exposed. Under this fascia and adherent to it over an area 2 centimeters square was seen a bluish tumor mass. The fascia was incised laterally to the tumor, exposing it, whereupon it was seen that the apparently angiomatous mass completely interrupted the course of a thin tendon of the peronei group, running down to the cuboid. This probably was the peroneus cuboideus tendon. (Cunningham, in discussing these anomalies of the peroneal tendons, states that the peroneus longus and peroneus brevis may be fused together, and that additional slips may be present, such as the peroneus accessorius, the peroneus digiti quinti, the peroneus calcaneus externus, and the peroneus cuboideus). The tendon, above and below the tumor, frayed out to disappear into it. The tumor had no pedicle. It was located 10 centimeters below the origin of the muscle belly.

The tendon was severed above and below the tumor, which was removed with the portion of the vaginal fascia investing its superior surface. The distal end of the tendon was sewed to the peroneus longus and the wound was closed in layers. Healing was uneventful. The tumor apparently had its origin in the tendon.

The pathological report made by Dr. Hansmann was as follows: the specimen consisted of a fusiform mass of tissue. At each end of the mass was a tendon which appeared to be frayed as it entered the mass. The mass was red and on section appeared to contain blood. The tissue was soft and did not have any characteristic appearance, but suggested more than anything else a hæmorrhage into the tendon sheath. Microscopically, the tumor consisted of many papilla-like projections which were lined by endothelium. Between the projections were collections of blood. The tumor was probably a cavernous hæmangioma. Another section taken through the tendon and the tumor showed the tumor infiltrating the tendon distally and proximally. In places only a few strands of tendon tissue remained to separate cavernous spaces (Fig. 2). In the center of the tumor no evidence of tendon structure could be made out. The exact origin of the tumor could not be determined but it was most probably from the tendon

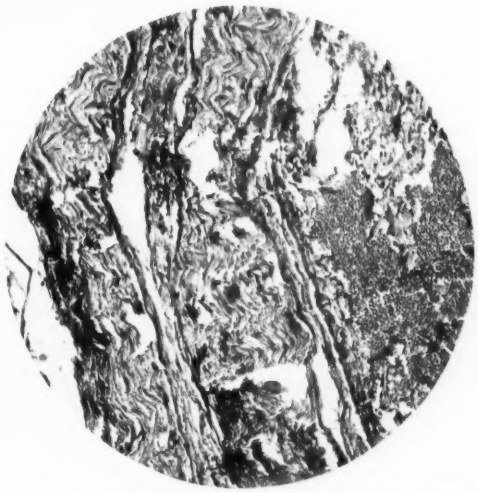

Fig. 2. Cavernous hæmangioma has invaded peroneal tendon. Tendon tissue on left. Tumor on right. (4 millimeters Leitz objective.)

itself since no definite sheath was seen. (Tendons which pursue a straight course need no sheath, according to Mayer.)

The patient was seen again in December, 1928, and was symptomless. No recurrence was noticed.

Case 4. Miss M. W., aged 22 years, complained of a nodule of 17 months' duration in the left popliteal space. Seventeen months prior to admission, the patient had had a generalized attack of joint pains, involving most of the joints. This passed and left no residua in its train. A few weeks later, the patient had noticed a small mass behind the left knee. It had fluctuated in size and at times the back of the knee had seemed swollen. At the time of examination, it was not as large as it often had been. It occasioned her some discomfort, since she felt it move about, as the knee was flexed and extended.

Along the internal border of the popliteal space, there was a walnut-sized, firm, discrete mass, not subcutaneous, which became apparent when the knee was extended and which slipped under the hamstring tendons when the knee was flexed. It was slightly tender to pressure. General examination was negative. The pre-operative diagnosis was either fibroma or chronic bursitis.

The operation was performed by Dr. Miltner, July 1, 1928. An incision 3 inches long was made over the internal hamstrings, 2 inches above the knee joint. Originating from the semi-tendinosus tendon was a white tumor, 5 by 2 by 2 centimeters, firm to palpation, and separate from the vaginal fascia above it. Its base of attachment measured 2 by 1 centimeters. There was little bleeding when the pedicle of attachment to the tendon was severed. The operative diagnosis was fibroma. The post-

Fig. 3. Sclerosing capillary hæmangioma. Beneath the capsule appeared endothelial lined spaces. Lower half of section is of hyalinized connective tissue. (16 millimeters Leitz objective.)

operative course was uneventful. The patient was discharged symptomless and was still without symptoms 6 months later.

The pathological report by Dr. Hansmann showed that the specimen consisted of a very firm white tumor, 4½ by 2 by 1 centimeters. The mass was fairly well encapsulated and appeared to be made up of layers of connective tissue. Between the layers of fibers were slit-like spaces which appeared to be lined by synovia. The tumor was definitely a fibroplastic neoplasm. Microscopically, the neoplasm had a definite capsule. The tumor showed many small blood vessels, the majority of which were capillary in size and many of which were not yet canalized. These vessels were all lined by endothelium. In a few places there was a perithelial growth with concentric layers of endothelial cells. The central and major portion of the mass consisted of interlacing bundles of hyalinized connective tissue. The tissue outside the capsule was very acellular, with the capillary spaces sclerosed. The pathological diagnosis was a sclerosing type of capillary hæmangioma (Fig. 3).

CASE 5. H. C. S., aged 57 years, was admitted January 2, 1929. He complained of swelling of the volar surface of the wrist and pain in the wrist and fingers of 2 years' duration. The onset had been insidious, and the complaints had gradually grown worse, especially during the past year. Recurrent attacks of pain radiating into the fingers had bothered him considerably. There had been a steady increase in the size of the wrist swelling during the past year. Nothing seemed to make it smaller. General history elicited nothing relevant. There was no familial tendency to angiomata or congenital anomalies. The general examination showed nothing unusual. No skin nævi were found.

The right hand was reddish, cold, and perspiring. On the volar aspect of the right wrist appeared a soft, non-tender swelling. It covered the lower quarter of the forearm and seemed to be divided into two lateral portions by the flexor tendons. When the wrist was flexed and the finger flexors contracted, the tumor almost disappeared, apparently being located below the vaginal fascia. The skin and subcutaneous tissue were freely movable over the mass. No nodules were palpable. Movements of the wrist and fingers were entirely free. Tendon contraction elicited an aching pain in the palm and fingers, especially the middle finger. X-ray was negative. Blood pressure was 190–98. The preoperative diagnosis was hæmangioma or myeloma of the flexor tendon sheaths.

The patient was operated upon by Dr. A. Steindler January 23, 1929. A midline incision 5 inches long was made over the volar surface of the wrist, severing the carpal ligament. Beneath the vaginal fascia but not adherent to it was a blue-red spongy layer enveloping the flexor tendons and the ulnar and median nerves. This neoplastic tissue extended along the tendons into the palm of the hand. Upon incision, it bled moderately. It did not seem to infiltrate the tendons, muscles, or nerves, but simply to adhere to them. It was easily stripped off. The tendons were stained a bright canary yellow. All visible tumor tissue was carefully dissected out and the wound closed in layers. The patient made an uneventful recovery. Five weeks later he had no pain. The fingers appeared to be a little stiff, he believed, but improvement was continuous.

Dr. Hansmann made the following pathological report: the sections showed a rather vascular tissue with abundant yellowish brown pigment, both extracellular and intracellular (phagocytosed). New capillary vessels were being formed or attempts at such were being made even though the lumina were devoid of blood. This, therefore, was a capillary hæmangioma and the pigment was the result of degenerated blood from hæmorrhage. The tendon, except for its yellow stain, grossly showed nothing remarkable. There was no involvement of the tendon tissue. The diagnosis was capillary hæmangioma (Fig. 3).

CASE 6. Through the kindness of Dr. Carl Mathewson of Fresno, California, we are enabled to report the occurrence of a hæmangioma recently removed from the tendon of the plantaris muscle in the clinic of Dr. Wilkie at the University of Edinburgh. The tumor appeared in a female aged 26 years and had been present for several years. It had commenced increasing in size 2 years before admission. There had been no pain. On operation it was found to be the size of a lemon and as firm as one. It was encapsulated and arose from the tendon of the plantaris muscle. Pathological section revealed a cavernous hæmangioma. A slide which we were

able to examine was of tissue closely similar to that of the tumor in Case 3. No evidence of malignancy was apparent.

ETIOLOGY

Buxton has wondered why tendon sheath tumors are not more common since the sheath is only a specialized connective tissue, and since tendons are often exposed to trauma and to the irritative processes of infection. It is equally a matter for speculation why angiomata of tendons and their sheaths are so rare. Mayer in his work on tendons has demonstrated that their blood supply, although much less than that of muscle or the neighboring connective tissue, is much better than has been taught. Except near its friction-bearing surface, tendon tissue contains numerous blood vessels, derived mainly from 3 sources: (1) the muscular branches; (2) the vessels running in the paratenon, mesotendon, and the vincula; and (3) the vessels from bone and periosteum near the insertion of the tendon. Yet these vessels are rarely subject to angiomatous change, it would seem. A tendon sheath and a joint are analogous structures, functionally and anatomically. It is interesting to observe how uncommon angiomata are in both structures.

As regards the ultimate etiology, it is Ewing's opinion that certain vascular segments retain their embryonal character and that the congenital origin of the tumor bespeaks a tissue predisposition. Ribbert suggested that the tumor process, an aberrant vascular germ, resides in an isolated segment of the vessel wall and that, after it has been latent for a time, it develops independently into a tumor. Among other hypotheses may be mentioned the fissural theory of Virchow and that of Rokitansky and Borst wherein angiomata represent simple hypertrophy of vascular segments without neoplastic tendencies.

Angiomata in general appear to be congenital. Fitzwilliams, in a study of 645 cases of angiomata, found 83.2 per cent which had been observed at birth, and an additional 12.7 per cent which had appeared during the first 3 years of life. Sixteen per cent of the patients volunteered a positive family history. However, of the tendon angiomata reported, only 3 had been noticed at birth. No one of these 3 presented a positive family history. The influence of trauma is very questionable. It may serve only to attract attention to the tumor. Trauma occurred in more than one-half of all the cases previously reported as well as those in our series, but was usually mild. Two-thirds of the patients were women. This corresponds to the observation that most types of angiomata apparently occur more often in women. In the first decade of life there were 3 cases; between the ages of 20 and 30 years there were 6 cases; and between the ages of 40 and 50 years there were 3 cases; and there was only 1 case in the sixth decade. The age was not stated in 2 cases.

SYMPTOMS

Pain is typical as a symptom and Weil believed it to be due to angiolithic concretions, rather than to nerve pressure. While this may be true in some cases, yet in Partsch's case (reported by Weil) the pain was typically over the distribution of the median nerve and over the dorsal branch of the radial nerve; while in our Case 5, the pain was referred along the distribution of both the median and the ulnar nerves. Pain is usually absent for a long time and manifests itself most often with an increase in the size of the tumor. Pain may appear soon after the initial trauma or may develop much later. It varies commonly from a sensation of discomfort to steady, continuous aching. More rarely, it may be described as sharp and cutting. Excision of the tumor is usually followed by complete relief of pain, while recurrence of the growth is accompanied by recrudescence of pain.

The patient as a rule notices the swelling late, as in our Case 3, where it was overlooked for 4 years, as a study of a series of photographs later revealed. Trauma may direct attention to the tumor. The swelling may vary in size and is often dependent on the position of the limb. Ulceration of the skin is reported in one case. As a rule, the skin is not adherent to the tumor, since the tumor lies beneath the ensheathing or vaginal fascia of the extremities. In most cases, the tumor remained unchanged in size for years, or increased very slowly coincidentally with the

general growth. In other instances, the growth was rapid at first, but later became stationary. In still others, at some period in the history of the tumor, generally following a mild trauma, it began to enlarge rapidly.

Functional restriction is usually absent for years, or may be very mild. In the upper extremity, extension of the fingers may be interfered with. Finger and wrist movements may feel stiffer than normal, and pain may be elicited in executing complicated movements, as in piano playing. Movements of the thumb may be lessened to the point of fixation. During illness, as in measles, one patient developed clonic tremors of the flexed hand and wrist. The effect of menstruation and of gestation has not been remarked upon. In the lower extremity, there may be present a mild limp. Equinus developed in one case (Schwartz). Sensory changes do not occur, apparently, though one patient complained of formication in the fingers.

SIGNS

The size of the tumor varies. It may be as small as a hazelnut or larger than a fist (cf. Case 6). In its growth, it may ulcerate the skin (Delagenière) with the production of a serosanguineous discharge. The tumor may be discrete and sharply outlined, or it may be diffuse, poorly outlined, and irregular, so that, at operation, it is usually larger than anticipated. Its consistency, soft, firm, fluctuant, or elastic, depends on the amount of fibrous tissue present. It may be painful to pressure and to touch, or only to pressure. This latter is attributed to the angiolithic concretions which may be outlined as tender nodules on palpation of the mass. Its composition is not always uniform, since it may also contain thrombi and dense connective tissue strands. The tumor may be reducible or irreducible, this factor being possibly determined by the ratio of fibrous tissue to angiomatous tissue. In some cases, an increase in the size of the tumor can be observed when the limb is in a dependent position and a decrease in size can be noted when the limb is elevated. Circular compression of the limb may increase the size of the tumor. With the pendent position of the limb, the overlying skin may appear deeper hued, even violaceous, and varices may appear. Varices, large enough to resemble a varicose tumor, have been reported present at the base of the tumor.

The tumor may pulsate. A souffle, soft and intermittent, may be heard. Seldom is a thrill felt. In 2 cases, subcutaneous angiomata of the finger tips were concomitant. It is noteworthy, however, that no case showed skin nævus over the tumor. Monod describes a peculiar discoloration of the skin, sometimes associated with deep angiomata, which may be caused when the tumor breaks through the vaginal fascia. However, until the tumor involves the vaginal fascia and subcutaneous tissue, the skin will remain freely movable over it.

In advanced cases (as Case 2) involvement of the adjacent muscle may occur. The localizing signs are indicative of the intimate attachment of the tumor to a tendon or tendons. Pain on motion may be elicited and disturbance of function frequently observed. The tumor may be palpated, may be made to stand out, and may be seen to move with the tendon (Case 4). It can, therefore, be moved horizontally much better than vertically. The tumor may obliterate tendon prominences. In the wrist, the tendons have been observed to overly the tumor and divide it into two lateral portions (Case 5). The tumor may follow the course of the tendon or sheath involved and may extend below the annular ligament of the wrist (Case 5).

PATHOLOGY

These angiomata tend in statistics at least to favor the left side of the body. They are not symmetrical, as lipomata tend to be (Stewart and Bettin). Their favorite site is in the lower third of the forearm. Both the upper and lower extremities may be involved, the upper much more frequently. In the upper extremity, the tendons involved, in their order of frequeney, have been: flexor profundus digitorum; flexor sublimis digitorum; carpal flexors of wrist; supinator longus; abductor pollicis; extensor longus pollicis; and extensor carpi radialis. The growths seem to favor the flexor side but may involve the extensor side by extension (Partsch). In the lower extremity the following were each in-

volved once: the tendon of Achilles; the extensor of the fourth toe; the semi-tendinosus; the quadriceps; an anomalous peroneal tendon; and the tendons in the medial aspect of the ankle, tibialis posticus, and flexor hallucis longus. No cases of multiple extremity involvement are reported. The tendons and the tendon sheaths of the fingers apparently escape.

Macroscopically, the tumor appearance is fairly typical, although it may look like a fibroma. One type (Cases 2 and 5) apparently originates from the tendon sheath and may not involve the tendon (Case 5, where red clusters of tumor lay free between the uninvolved flexor tendons at the wrist). Another type originates from the tendon (Cases 1, 3, 4, and Schwartz's case). In this the tendon is infiltrated by the tumor tissue, which may disrupt its fibers and destroy it, with interruption of continuity (Fig. 3). The tumor arising from the sheath envelops the tendons, especially at the wrist, and ultimately may become adherent to them so that dissection may be difficult. The tendons in Case 5 were stained a remarkable canary yellow color, presumably from the blood pigment released in repeated extravasations following injuries to the thin walled sinuses. The discrete sclerosing forms are apt to be attached by a definite base to the tendon; the diffuse forms tend to infiltrate the neighboring tissues, whether fascia, muscle, or tendon, forming many nodules, pin-sized to lentil-sized, aggregated in red clusters. The mass may be well encapsulated or poorly so. The color of the tumor is usually bluish-red. A definite pedicle is not made out in the tumors arising obviously from the sheath. In the more diffuse types, isolated angiomata of muscles may be present. Muscle invasion may extend to the point of replacement by tumor. The nerves are not infiltrated, running unchanged through the tumor mass (Case 5).

Grossly, the tumor usually shows many spaces lined with a shiny membrane and filled with fresh blood. It is usually soft and red on section, though it may not always be so, depending on the amount of fibrous tissue, thrombi, and concretions present. The color may vary from light brown to red and the surface of the cut section may be striated. The microscopic structure of these tumors is usually that of cavernous angioma. Two of the present series were of the capillary angioma type with an unusual amount of fibrous tissue. The tumor may be of the mixed type and may contain cartilage and fibrous tissue (Chauvin and Roux). Metastasis does not usually take place, though it occurred in Faldini's case.

DIAGNOSIS

The diagnosis is usually difficult, especially in the discrete type. The clinical history is helpful. The presence of skin angiomata may be suggestive, as in our Cases 1 and 2. Preoperative aspiration of the tumor will show fresh blood. The X-ray may demonstrate the presence of angiolithic concretions. Ruggles recently has again called attention to this. These concretions appear as numerous, small, cyst-like masses, varying from 1 millimeter to 1 centimeter or more in diameter, with a thin shell, an irregular mass in the center. The spots are scattered throughout the tumor and are taken to represent calcification of thrombi in the cavernous loops.

DIFFERENTIAL DIAGNOSIS

Juxtatendinous affections are not always easily delimited and many cases have been mistaken for tendon sheath tumors, though seldom for angiomata. Malignancy of the skin is not likely to be confusing. Tumors of the vaginal fascia, myelomatous (Christopher) and angiomatous (Biancheri) are reported. Biancheri described an angioma arising from the vaginal fascia over the vastus internus, which had become adherent to periosteum and bone. This very probably originated in the vaginal fascia which, on the inner side of the thigh, blends with the muscle fascia over the adductors and runs down to insert into the femur along the inner lip of the linea aspera.

Tumors of muscles, especially angiomata, develop at the level of the muscle belly. Differentiation may be difficult, however. Localized myositis ossificans may also be confused in this connection. Periosteal affections, especially tumors, may invade tendon sheaths secondarily. The converse may be true, that a tumor of a tendon sheath, usually sarcoma,

may adhere early in its development to the periosteum. Diagnosis is easy at first but difficult later. Methodical palpation and the roentgenogram provide help. Gangolphe described a periosteal angioma. It contained angioliths which produced crepitation mistaken for that of rice bodies.

Other tumors of the tendon sheaths, such as myelomata, lipomata, fibromata, chondromata, and sarcomata, are to be differentiated if possible.

Myelomata of tendon sheaths are by far the most common and important. Tourneaux in 1913 collected 54 cases of this type from a series of 93 tendon sheath tumors. The German authors call them xanthomata, xanthosarcomata, and giant cell sarcomata. The disease occurs more often in the upper extremity, more often in males, and more often in the fingers and palm of the hand than in the forearm. The lower extremity may be involved. The tumor may arise at any age, from 6 to 80 years, most frequently between 10 and 40 years. The duration of development has varied from 3 weeks to 20 years, with an average of 1 to 4 years. The tumors on the forearm are most malignant, while those on the fingers and palm are much more benign (Krogius, Rosenthal).

In Tourneaux's series recurrences were noted in 21 cases, of which 6 cases showed metastases to liver, lungs, etc. Rosenthal reported 71 cases in 1909 with 15 recurrences. It is interesting to note that many observers have recorded the presence of skin xanthomata and a high cholesterin content in the blood in this disease. The latter has been invoked as a causal factor (Hoesslei, Pincus and Pick, Pringsheim). Hartert believes that myelomata of tendon sheaths are different from myelomata of bone, while Ely has reported a case of simultaneous bony and tendon myelomatous involvement. Myelomata are apparently encapsulated, often lobulated, and moderately firm or elastic. The microscopic picture presents a characteristic triad.

Giant cells or myeloplaxes, first described by Heurteux, are always present and contain a variable number of nuclei. In the tumors of the forearm, they may be difficult to find. Lipoid cells, first described by Dor in 1898, are large, vesicular, and bright. The nuclei are round or oval, often eccentric. There is much fat in the cell, which doubly refracts and stains with Sudan III. This fat is the cholesterin ester of a fatty acid. Blood pigment, either extracellular or intracellular, giving the Prussian blue reaction for hæmosiderin, is regularly found.

Lipomata of tendon sheaths are uncommon but 18 cases were reported up to 1922 by Strauss. There are two usual forms, the simplex and the arborescent. The age at which onset occurs ranges from 2 to 34 years. The duration of symptoms is very long, averaging 26 years. Symmetrical distribution and multiplicity of the lesions are occasionally observed. The lipoma may surround the tendon longitudinally and follow it to the tendon insertion, producing a cylindrical swelling which may crepitate. Another form attaches itself to the outside of the sheath by a pedicle. The site of predilection is the palm of the hand. Lipomata may destroy joints, bone, and periosteum by direct infiltration. In a case of White a lipoma arising from the peroneal tendons destroyed the tarsal joints, necessitating a fusion operation.

Fibromata of tendon sheaths are uncommon, and only 13 cases have been recorded. These tumors grow slowly, rarely reaching a large size. They are usually located on the flexor tendons of the palm. Ombredanne in 1907 reported 7 cases, none with sarcomatous elements. Hansmann is inclined to believe that, in most so-called fibromata, if one seeks carefully on the edges of the tumor, one may see a different pathological picture. The fibrous tissue of the fibroma is only the end-result in many. Case 4 (and, in all probability, the case of Schwartz) which grossly appeared to be a fibroma, presented definite evidence of a hæmangiomatous character at the periphery of the tumor.

Chondromata of tendon sheaths usually have a definite history of trauma. Only 9 cases have been recorded (Janik). These chondromata are small, hard, and discrete, and also may be lobulated. The tumor, in each instance, is composed of islets of hyaline cartilage, interspersed among areas of fibrous tissue. Calcification and ossification may take

place. They may occur in conjunction with the cartilaginous tumors of bone (Buxton).

Sarcomata of tendon sheaths are malignant and infiltrating. About 47 cases have been recorded. Ayres and Markoe early outlined the syndrome. As a rule, myeloplaxes are absent and there is no lipoid. Mixed tumors not infrequently appear.

Tumors of tendons proper are comparatively rare and Ombredanne and Buxton believe they do not exist. They think that the growth arises primarily from the tendon sheath and that the tendon is simply encroached upon. In an advanced case, it is difficult to feel sure as to the origin of the tumor. Angiomata, as in Case 3, have hitherto not been reported. Fibromata, osteomata, and sarcomata are recorded. Buxton believes osteoma of tendon to be a disease akin to myositis ossificans. Ollerenshaw has described a bilateral giant cell sarcoma apparently primary in the tendo achillis associated with xanthelasma. Jolkwer reported a unique cysto-endothelioma of a tendon, occurring in the flexor tendon of the middle finger. The tumor contained a thick gray fluid and was composed of concentric layers of endothelial cells. A similar case has been observed by the present authors. The so-called tendon ganglion as described by Thorn belongs to this group.

Inflammations of tendons and their sheaths are the most common affections encountered in diagnosing tendon lesions. Traumatic, pyogenic, gonorrhœal, syphilitic, and tuberculous tenosynovitis form a group whose description is not within the scope of this paper. The neuropathic tenosynovitis of Chipault deserves note. Aspiration will decide the diagnosis in many cases in which the history, physical examination, and X-ray findings are inconclusive. Rheumatic tenosynovitis may occur in conjunction with arthritis. Baracz reported on tendinitis arthritica achillea in rheumatic patients. The swelling surrounds the tendons and extends from the heel insertion to the origin of the tendon. Single nodules in the tendon are often palpable and the author conceives them to be depositions of urates. It is undoubtedly more common than the sparse accounts would lead one to believe. Since tendon sheaths are akin to joints and bursæ this picture is probably correct. This may be the fibroformative tenosynovitis of which Tourneaux speaks. It may simulate a tumor due to its papillomatous outgrowths. Similarly, chronic inflammatory tumors of tendons have been described by Forgue (Tourneaux) and Klots. The ganglion, a degenerative cyst of the tendon sheath wall, is not likely to occasion confusion. Its location and character are fairly typical. The recent article of Carp and Stout covers the subject comprehensively.

PROGNOSIS

The outlook in angiomata of tendon sheaths is good, both in regard to the lack of recurrence and ultimate good function. Many cases are definitely cured. In the diffuse, infiltrating types, recurrence may take place. Yet the prognosis, even in these, is fair. Function in all cases was good. If we exclude the case of Faldini, there has been observed no tendency to malignancy or metastasis.

TREATMENT

Radical excision of the tumor, whenever possible, is the treatment of choice, and this was the procedure followed in every case, except that of Richet, in which a coagulating material was used. One case had X-ray treatment for recurrence following excision. The treatment was apparently successful only in so far as no additional recurrence appeared during a year's observation. In the treatment of angiomata in general, considerable success has been reported. Thus Andrén recommends filtered radium emanations in the treatment of deep angiomata, using small doses at intervals of considerable length. Of 59 deep angiomata seen by him, 45 were so treated. Of these cases, 28 were reported cured and 15 improved. Eller similarly prefers the use of radium. He also advises the use of bipolar endothermy. Ludwig von Babo 50 years ago recommended the use of many irritating substances for injection, such as sulphuric acid, iodine, bichloride of mercury, and trichloracetic acid. Thermocautery and galvanocautery have been used. Spontaneous involution may rarely take place in cases of angioma by increasing fibrosis.

We are indebted to the kindness and courtesy of Dr. Arthur Steindler for the inclusion of the cases of the department, to Dr. H. L. Beye for the use of Case 2, and to Dr. G. H. Hansmann and the Department of Pathology of the University for their generous aid. The anatomical conception of the vaginal fascia as referred to in the mention of the lateral compartment of the leg, the popliteal space, and the forearm, is that of Dr. H. L. Prentiss, of the Department of Anatomy.

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MIXED TUMORS OF THE TONGUE AND SUBLINGUAL GLAND

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NEOPLASMS of complex structure, usually referred to as "mixed tumors," are not rarely encountered in the salivary glands, buccal mucosa, palate, lips, and orbit. They vary widely in histological appearance, but usually have two essential features in common: (1) epithelial elements arranged in solid masses, strands, or alveoli; and (2) "mesothelial" elements in the form of hyaline cartilage, mucous tissue, or immature fibrous connective tissue. Often polyhedral or fusiform cells, similar in appearance to mesoblastic cells, are also found, but these may be traced through transition forms to origin from the epithelial elements present in the neoplasm.

Furthermore, in the regions mentioned, there occurs a type of neoplasm characterized by cuboidal epithelial cells arranged in tubular structure and solid "cords." These tubules or cords are separated from one another by dense fibrous connective tissue septa in which there is often hyaline change. Neoplasms of this type closely resemble basal cell or adenocystic carcinoma. In the past most authors have regarded them as a variety of mixed tumor, and have called them cylindromata. This term, however, is not specific. It was first introduced by Billroth and has since been applied to various unrelated types of neoplasms in which elongated masses of tumor cells are separated by connective tissue septa exhibiting hyaline change.

During the latter part of the nineteenth and the beginning of the twentieth centuries a stubborn controversy existed concerning the origin of mixed tumors. Volkmann propounded the theory of endothelial origin, while Planteau, Mallassez, and others believed them to be carcinomata. Later Krompecher concluded that they were entirely of epithelial nature, even the cartilage and mucous interstitial tissue being derived from metaplasia of the epithelial cells. In summarizing the question, Ewing states: "(1) The theory of endothelial origin of mixed tumors has been disproved. (2) No single source of mixed tumors meets all requirements. Some are distinctly adenomatous and probably arise from acini and ducts of the gland in which they are well incorporated. Others are encapsulated or extraglandular and take the form of basal cell or adenocystic epithelioma. These probably arise from misplaced and occasionally embryonal portions of gland tissue. Bronchial elements may possibly be connected with this group. (3) The derivation of mucous tissue and cartilage from gland epithelium has been satisfactorily proved, and there is no necessity of including in the originating tissue any cartilaginous structures." In short, the carcinomatous nature of malignant mixed tumors has become generally recognized.

Because of the difference of opinion as to the true nature of mixed tumors in the early literature, many other terms were applied to them, especially when they occur about the buccal cavity. Some of these were: angiosarcoma, endothelial sarcoma, plexiform sarcoma, lymphangiosarcoma, myxosarcoma, and endothelioma. This, of course, has led to considerable confusion and false classification, for the same terms have been applied also to neoplasms which are definitely not mixed tumors.

MIXED TUMORS OF THE SUBLINGUAL GLAND

Whereas much has been written concerning the salivary glands as a group, the literature contains but few specific references to neoplasms of the sublingual gland. Wagner observed a chondroma of this gland, and Zeisl and Nicoladoni each an adenoma. Mixed tumors of the sublingual gland are very rare. A review of the literature has yielded only the two case reports which follow:

CASE 1. From Barth. The patient, a male, aged 67 years, first noticed a small mass the size of a lentil, on the floor of the mouth beneath the tongue, 2 years before he presented himself for medical attention. This gradually increased in size until it filled

the entire left side of the floor of the mouth. The tumor mass within the mouth was not tender but the tongue which was pushed to the right was always painful. Heat on the tongue increased the discomfort; cold was grateful. Recovery took place and there was no recurrence several months after operation, when the tumor was removed *in toto* and was found to include the entire sublingual gland. The histopathological diagnosis was lymphangiosarcoma. From the description and illustrations, however, the true nature of the neoplasm is seen to be a mixed tumor. (Heinecke concurs in this opinion.)

CASE 2. From Heully and Boeckel. The patient, a male, aged 39 years, complained of a small mass in the region of the right sublingual gland, of 4 years' duration. There was no pain, but medical consultation was sought because of the gradual increase in the size of the mass during the previous 18 months. On examination the tumor in the region of the right sublingual gland was found to extend from the mandible anteriorly to the base of the tongue posteriorly but not into this organ. The mass was firm, encapsulated, not tender, and was easily movable on surrounding tissues. The overlying mucosa was slightly injected. No enlarged regional lymph nodes were found. At operation the tumor was easily shelled out and patient remained free from recurrence for several months. The histopathological diagnosis was cylindroma (benign) of the sublingual gland.

In addition to these observations 2 others must be mentioned: (1) Heinecke observed a mixed tumor in the floor of the mouth (*Mundboden*) which was removed without recurrence; and (2) Ribbert described a malignant cylindroma in the same location with metastases to the peritoneum. In the absence of specific descriptions as to the relations of these tumors to the sublingual gland, they cannot be regarded as neoplasms of the latter.

In the case report which follows not only is there an instance of a mixed tumor (cylindroma) of the sublingual gland, a condition which, as has been shown, is extremely rare, but also there is an example of a mixed tumor of 19 years' duration which became malignant in the last several years and has caused extensive local destruction and producing metastases. Fortunate circumstances have enabled the writer to procure for histological study tissue removed in 1910, at the onset of the process, and in 1927, when a biopsy was performed upon the lesion.

CASE 3. E. H. D., cachectic white female, 60 years of age, a physician, was admitted to The University Clinics January 11, 1929, because of marked weakness and inability to speak and to swallow, due to a large defect in the right side of the mandible with a large fistulous opening. In 1910, the patient had first noted a "small growth" in the right sublingual gland. This was "removed" under local anæsthesia. The details of the history were not available from that time until 1922 when the patient noted swelling on the internal surface of the body of the mandible on the right side. This swelling was complicated by an abscessed tooth in the same region. Incision and drainage of the abscess afforded relief but the wound did not completely heal. In 1923, a pathological fracture occurred in the right side of the mandible, in the region of the first molar. The wound made for incision of the abscess continued to discharge, and pieces of bone were extruded at intervals. In 1927, a biopsy in the region of the wound was performed and "an opening was made in the floor of the mouth." The diagnosis from biopsy was "mixed tumor—so-called cylindroma." Roentgen-ray therapy was employed at that time. In 1927, a roentgenogram of the mandible showed erosion of the right side of the body to the ramus. The personal and family histories were irrelevant.

Physical examination revealed a markedly cachectic, elderly, white female, unable to speak except for a few guttural sounds. The lips could be separated for a distance of only 1.5 centimeters, but this caused much pain. The few remaining teeth were covered with much foul caseous material. In the right mandibular region and extending on to the neck was a large, irregular, fistulous opening about 6 centimeters in diameter, communicating with the mouth and pharynx. In the center of the cavity a whitish, oval mass was seen. The upper part of the epiglottis also was visible through the opening and was seen to be eroded. Physical examination was otherwise essentially negative, as far as could be determined, except for the rapid heart rate (110 per minute), and slight blowing diastolic murmur over the apex. The blood pressure was 84–50; urinalysis was negative; the white blood cell count was 10,000; and the Wassermann and Kahn tests were negative. Roentgenograms of the skull showed absence of the right side of the body of the mandible to the ramus.

Clinical diagnosis: slowly growing malignant tumor, probably of sublingual gland.

A Witzel gastrostomy was performed (Dr. L. R. Dragstedt) for the purpose of nourishing the patient. Local anæsthesia was used. Milk and glucose solutions were introduced into the stomach and well tolerated. The following day the remains of the tongue were found protruding from the large opening in the form of a round, whitish, firm mass about 4 centimeters in diameter, attached by a slender fibrous cord-like pedicle. This was severed and the tongue removed. The next morning dyspnœa suddenly developed, and ½ hour later the patient died.

Necropsy was performed by Dr. Béla Halpert. The abstract of his anatomical diagnosis follows: "Carcinoma of the mucosa of the mouth, with destruction of the apex and corpus of the tongue, the

Fig. 1. Case 3. E. H. D. Large fistulous opening in right mandibular region and neck due to erosion by malignant mixed tumor type cylindroma developing originally in right sublingual gland.

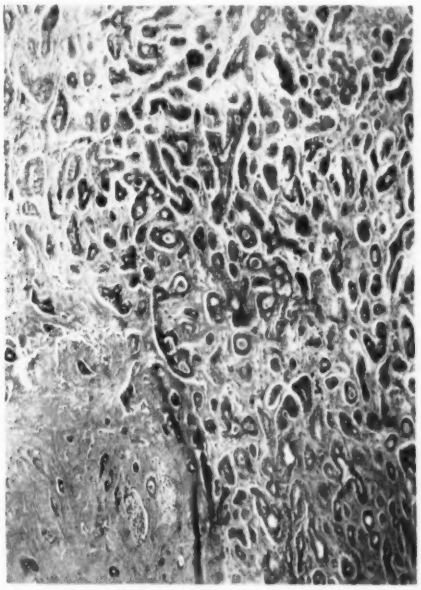

Fig. 2. Case 3. E. H. D. Section from mixed tumor of right sublingual gland removed in 1910. Neoplasm is composed of tubular structures separated by connective tissue septa in which there is hyaline change. A large area of dense connective tissue in which there is hyaline change is also present. ×65.

floor of the mouth, the right half of the mandible, the soft parts of the mental, submental, and right submandibular regions up to the level of the hyoid bone with exposure of a part of the left half of the mandible and the upper surface of the hyoid bone. Deformity of the entrance of the larynx and marked œdema of the mucosa. Extensive metastases into both lungs, particularly the right with umbilication of the subpleural nodules and implantation metastases on the parietal pleura."

Microscopic studies: 1. Sections were cut from paraffin blocks of tissue (Zenker's solution fixation and Ehrlich's hæmatoxylin and eosin stain) removed at operation in 1910. These blocks, sections of which are shown in Figs. 2 and 3, were lent by Dr. R. R. Bensley. The sublingual gland was seen to be invaded by a neoplastic growth composed of tubular structures of various sizes lined by two layers of cuboidal epithelial cells. The cells of the inner layer were smaller than those of the outer layer. The nuclei were rounded and hyperchromatic, the amount of cytoplasm small. The individual tubules were separated by septa of dense collagenic tissue which in places exhibited hyaline change. In many instances several tubules were closely applied to one another without intervening fibrous tissue. The lumina of the tubules were for the most part empty, but some contained finely granular débris or large eosinophilic disc-shaped masses resembling concretions. In places there were large areas of dense collagenic tissue exhibiting areas of hyaline change and in which were scattered a few isolated tubular structures. No mitotic figures were found in the neoplastic cells in sections examined.

2. Tissue (permanent preparation of frozen section and hæmatoxylin and eosin stain), removed at biopsy June 3, 1927, was examined by Dr. H. Hartwell, of the Massachusetts General Hospital, whose report follows: the section (Fig. 4) was taken from a "tiny fragment of tissue showing on microscopic examination a structure of clusters of small, inactive epithelial cells forming tubule-like structures in a degenerative fibrous connective tissue stroma. The cells resemble those of basal cell carcinoma and the tubules suggest the cylindrical structure seen in cylindromata. The growth resembles the mixed tumor or cylindromata of the salivary gland and is of low degree malignancy."

3. Sections (alcohol-formol fixation and Ehrlich's hæmatoxylin and eosin stain) from the ulcerated area at the base of tongue (Fig. 5) removed January 15, 1929, the day before death, showed the crater of the ulcer to be composed of a very narrow zone of heavily infiltrated, œdematous, fibrous connective tissue. The margins of the ulcer were considerably undermined. Scattered throughout the deeper portions of the section, on each side of, and just beneath, the crater of the ulcer, were many small tubular structures whose walls were composed of one or two layers of cuboidal or polyhedral epithelial cells, with rounded, hyperchromatic nuclei and a small amount of cytoplasm. In these cells an occasional mitotic figure was seen. Not infrequently a structure which consisted of several tubules, closely applied to one another without

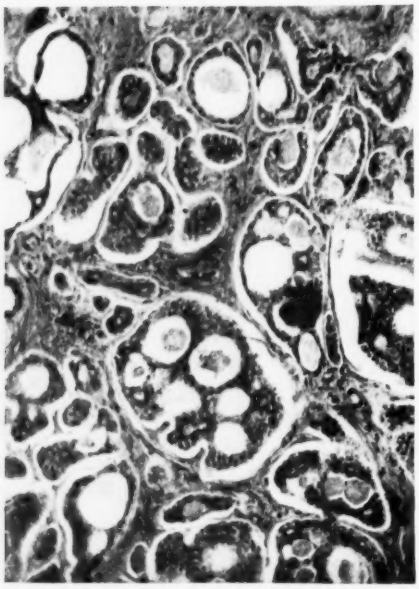

Fig. 3. Case 1. E. H. D. High power photomicrograph of portion of sublingual gland tumor removed in 1910. Structures are present which appear to be composed of several tubules closely applied to one another without intervening fibrous tissue. ×125.

intervening interstitial tissue, was found; but, in general, the individual tubules were separated by narrow strands of œdematous, fibrous, connective tissue in which there was moderate to dense infiltration by leucocytes.

4. Sections (fixation and stain as above) from the lung (Fig. 6) show just beneath the pleura a round neoplastic mass composed of tubular structures similar to those just described. Many of these tubules were larger than those seen in the previous studies, and the two layers of cuboidal cells lining them were in many places replaced by a narrow wall of closely packed polyhedral cells with small oval nuclei. Occasional mitotic figures were seen in the epithelial cells. The lumina, for the most part, were empty but a number of them contained granular débris and a few endothelial leucocytes. In some there was reticulated material or large, smooth, oval, lightly staining masses resembling concretions. This neoplastic growth was not separated from the lung parenchyma, which was normal, by a definite capsule, nor was there any leucocytic infiltration or exudation in the alveoli immediately surrounding it.

Attention must be called to the fact that in all these sections made from tissue removed at intervals over a period of 19 years, the character of the epithelial elements is essentially unchanged.

From a study of the sections and the clinical history, there would appear to be little doubt that the neoplasm was benign at the onset of development, but that it became malignant in the last several years, causing much local destruction and metastasizing to the lungs and pleura. This behavior, i.e., a long or short period of benign development preceding malignant degeneration, is characteristic of mixed tumors—particularly those of the parotid—which become malignant. The extensive and progressive local destruction present in the case just described is also characteristic of basal cell carcinoma, the type of neoplasm which the cylindroma (mixed tumor) so closely resembles.

By far the greatest number of mixed tumors occurring in the salivary glands are found in the parotid. In a series of 360 mixed tumors of the salivary glands collected from the literature and studied by Heinecke, 288, or 80 per cent, were found in this gland. The reason for this is not at all clear. Trauma is decidedly not a factor, since the sublingual glands are much more exposed than either the parotid or submaxillary. The parotid is purely a serous gland. The submaxillary is a mixed gland but predominantly serous, while the sublingual is also mixed but predominantly mucous. What significance, if any, from the standpoint of etiology of mixed tumors, this difference in histological structure has cannot of course be definitely stated.

Of the 3 cases summarized above, one was malignant, making the incidence 33 per cent; this is approximately the same as for the much greater series occurring in the parotid and submaxillary glands which, according to various authors, is between 25 and 30 per cent.

MIXED TUMORS OF THE TONGUE

Mixed tumor of the tongue also constitutes a rare condition. Rosenberg, in a review of the literature on neoplasms of the tongue, does not mention mixed tumors. Wilms, in an extensive treatise on mixed tumors in general, does not cite an instance of one which developed in the tongue. A few cases, however, have been recorded. In the majority of instances the diagnosis of mixed tumor was not made in the report of the case. Instead, one

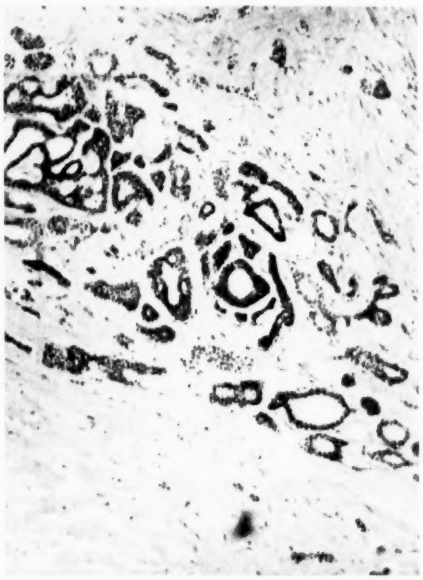

Fig. 4. Case 3. E. H. D. Section from biopsy of wound in mouth taken in 1927. Tubular structures scattered in dense fibrous connective tissue. ×65.

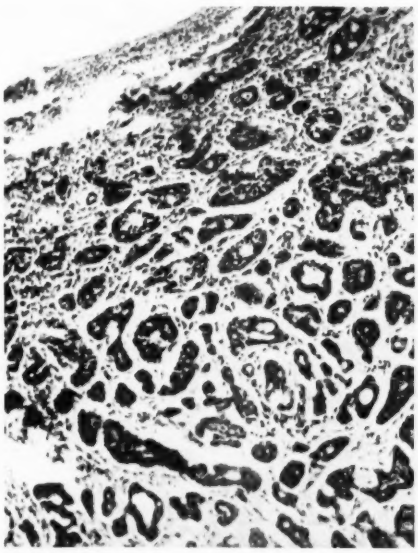

Fig. 5. Case 3. E. H. D. Section through ulcer at base of tongue (1929), showing floor of ulcer beneath which are many tubular structures. ×65.

of the many other vague terms used in the older literature was employed. In each instance, however, the writer has carefully studied the descriptions and available illustrations, and those which in his opinion were undoubtedly mixed tumors are included in the following series:

Case 4. From Luecke. The patient, a male, aged 36 years, had a slowly growing tumor in the left side of the base of the tongue. The tumor, though painless, was the size of a large walnut, had been present for 7 years, and interfered with deglutition. Excision was done. No diagnosis was made.

This was a cylindroma.

Case 5. From Godlee. The patient, a female, aged 24 years, presented an ulcerated tumor, with calcareous nodule in the center, on the under surface of the tip of the tongue. The tumor had appeared 5 weeks earlier. Excision was done and there was no recurrence. The histopathological diagnosis was adenocarcinoma or mixed cell sarcoma.

Case 6. From Santesson. The patient was an adult with a slowly growing infiltrating tumor in the left half of the tongue. First notice of the tumor was taken 3 years before. There was slight pain and at times considerable hæmorrhage. Metastases to the parotid gland seemed probable. The tumor was excised. The histopathological diagnosis was sarcoma plexiforme hyalinum.

Case 7. From Ewald. The patient was a female, aged 36 years, with an infiltrating tumor in the right side of the tongue near the base. The character of her voice had changed and deglutition was difficult. After excision, there was local recurrence in 1 year, followed by a second operation. The tumor recurred again 2 years later with metastases to the pharynx, the floor of the mouth, and the cervical lymph nodes. The histopathological diagnosis was cylindroma (mixed tumor).

Case 8. From Mercier. The patient, a male, aged 26 years, had had a slowly growing tumor of the anterior portion of the tongue for 8 years. Excision was done and there was no recurrence. The histopathological diagnosis was large mixed cell sarcoma.

Case 9. From Summers. The patient was a female, 32 years of age. She had a tumor, at the base of the tongue to the left of the midline, which was the size of a walnut. Difficulty in deglutition and the excessive secretion of saliva were present and there had been hæmoptysis on two occasions. Excision was done and the histopathological diagnosis was endothelioma or adenoma. This tumor resembled the "endotheliomata," i.e., mixed tumors, of the salivary glands, described by Volkmann.

Case 10. From Van Kryger. The patient, a female, aged 31 years, had a tumor at the base of the tongue in the midline. The tumor, which had appeared 2 years earlier, was the size of "half a cherry." It was excised and the histopathological diagnosis made was endothelioma.

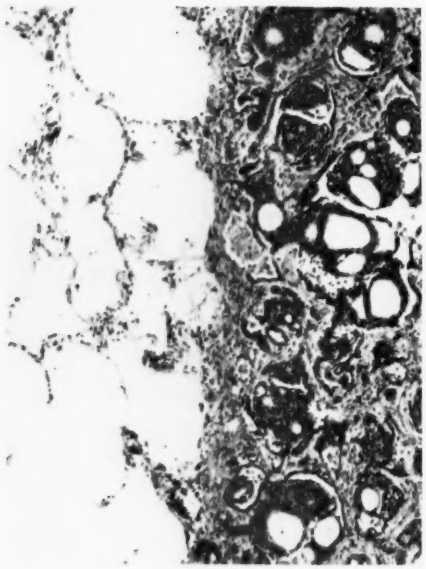

Fig. 6. Case 3. E. H. D. Section through margin of metastasis of cylindroma in lung, showing abrupt change from neoplastic to lung tissue. Pulmonary alveolæ bordering metastasis are normal. ×65.

This was in reality a cylindroma type of mixed tumor, in the interstitial tissue of which were epithelial cells morphologically resembling mesoblastic cells.

Case 11. From Scholle. The patient, who was a male, aged 78 years, had an encapsulated tumor, at the base of his tongue, 1 centimeter in diameter, found in routine examination at autopsy. He died following a cranial operation for trifacial neuralgia. The histopathological diagnosis was mixed tumor.

Case 12. From Quénu. The patient, a female, 50 years of age, exhibited a tumor, at the base of the tongue, "half the size of a cherry," encapsulated, and movable on the deep tissues, which was of several months' duration. There was no functional disturbance. Excision was done and the histopathological diagnosis was cylindroma (benign).

Case 13. From Preusse. The patient who was a male, aged 50 years, had an ulcerating tumor the size of a hazelnut on the left margin of the tongue. It had appeared only a few months before. Excision of the tumor and the regional lymph nodes was performed. The histopathological diagnosis made was cylindroma (no metastases).

Case 14. M. B., a white female, 66 years of age, was admitted to The University Clinics February 17, 1929, complaining of a swelling of 3 years' duration on the left side of the neck, and of "sore tongue" of 1 week's duration. The swelling was just below the angle of the mandible and when first noted was "the size of a bean." It had gradually become larger but had not interfered in any way with speech or deglutition. A week prior to admission the patient had developed a "cold" and at that time had noted a "soreness in the tongue" and in the mass in the left side of the neck. She then recalled that, on 3 previous occasions when she had had colds, the tongue and the mass in the neck had been "sore." For the first time, also 1 week prior to admission, another mass was noted on the left margin of the posterior portion of the tongue. The personal and family histories were irrelevant.

Physical examination revealed a small, elderly, well developed, and well nourished white female, not acutely ill. Physical findings were essentially negative except for an oval, firm, slightly tender mass, 4 centimeters long and 2 centimeters wide, in the upper part of the left anterior cervical triangle over the anterior margin of the sternomastoid muscle. This mass was not attached to the overlying skin, which appeared normal and was easily movable on the deeper tissues. On the left margin of the tongue, anterior to the circumvallate papillæ, there was a firm, whitish rounded area about 1.5 centimeters in diameter. The mucosa there was slightly raised and apparently intact, although it felt rougher and was paler than the rest of the surface of the tongue. The firm area extended into the deeper tissues and gave the impression of an infiltrating lesion. The blood pressure was 140–70; the urine was negative; the red blood cell count was 5,180,000; the white blood cells numbered 8,500; the hæmoglobin was 80 per cent; and the Wassermann and Kahn tests were negative. Roentgenograms of the chest showed the lungs and heart to be normal.

Clinical diagnosis: carcinoma of the base of the tongue with metastases to the cervical lymph nodes.

On February 18, 1929, a biopsy was performed upon the lesion in the tongue and at the same time twelve gold radon seeds, 0.98 millicurie each, were embedded concentrically about the tumor. Diagnosis from the biopsy was "mixed tumor" (see below).

Operation was performed by Dr. D. B. Phemister 9 days later for removal of the mass in the upper left side of the neck. This was found to be one of several enlarged, firm lymph nodes of the upper part of the deep cervical chain, surrounding and closely adherent to the internal jugular vein and to the lower portion of the parotid gland. To remove these lymph nodes, it was necessary to excise a segment of the internal jugular vein. The left submaxillary gland and lymph nodes also were removed. Convalescence was uneventful and the patient was discharged 11 days later.

Microscopic studies. 1. Sections (alcohol-formol fixation and Ehrlich's hæmatoxylin and eosin stain) of tissue removed from tongue at biopsy (Fig. 7) showed along the margin corresponding to the surface of the tongue no stratified squamous epithelium; instead, there was a very thin compressed band of fibrous connective tissue. Immediately beneath this was a rather broad zone of cuboidal to low

Fig. 7. Case 14. M. B. Section from mixed tumor in tongue showing papillary cystic structure and irregular masses of cells which resemble mesoblastic cells but which are in reality epithelial elements, scattered in stroma. ×65.

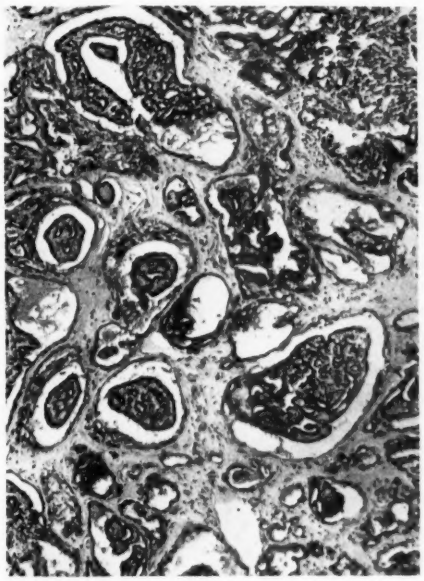

Fig. 8. Case 14. M. B. Section from metastasis of mixed tumor in large cervical lymph node, showing primarily papillary cystic structures which vary greatly in size. ×65.

columnar epithelial cells arranged in small closely packed masses, anastamosing cords or lying in single layers about small oval or irregular alveolar spaces. These cells exhibited large, round, hyperchromatic nuclei and small amounts of eosinophilic homogeneous cytoplasm. In the superficial portion of the section were oval papillary cystic structures also, the cyst cavities being lined by low cuboidal or flattened epithelium resembling endothelium. The cystic spaces were nearly filled with papillomatous masses composed for the most part of closely packed columnar or polyhedral epithelial cells, similar in appearance and arrangement to the cells described above.

Deeper in the section, the interstitial tissue became very abundant and varied considerably in appearance. In places it was composed of closely packed fasciculi of collagenic fibers, among which were thin, compressed fibroblast nuclei. Elsewhere it consisted of a light bluish, reticulated, and vacuolated ground substance (perhaps mucous tissue), in which were scattered rounded, wandering cells or fibroblasts, with large, rounded, finely stippled nuclei. In these deeper portions of the section were also widely separated masses of columnar epithelial cells, and irregularly shaped cells with rounded or oval nuclei and more abundant cytoplasm than in the epithelial cells previously described. These cells were arranged for the most part in large or small compact masses but, when seen in groups of two or three or even singly in the interstitial tissue, they closely resembled mesothelial cells. Numerous transitional forms between this type of cell and the columnar epithelial cell could be seen.

2. Sections (fixation and stain as above) through the large lymph node removed from the cervical region (Fig. 8) showed normal lymphoid parenchyma almost entirely replaced by a neoplasmic growth consisting of papillary cystic structures, varying considerably in size, alternating with groups of small alveoli lined by a single layer of low columnar epithelial cells. Between some of these alveoli were small masses of polyhedral or fusiform cells, closely resembling mesoblastic cells. The papillary cystic structures were similar in appearance to those described in the primary lesion above, except that some reached a much greater size and in two or three instances the papillary mass completely filled the cystic space, compressing the lining epithelium. In the central part of the section the papillary cystic structures were widely separated by bands of œdematous fibrous connective tissue. Nearer the periphery the stroma was less abundant. In these sections the stroma did not possess the mucous character seen in places in the primary lesion.

Subsequent history: the patient was seen on July 15, 1929. The wound in the neck was completely healed. There were no palpable masses present in this region. Deglutition and speech were

unimpaired. Examination of the tongue, however, revealed a well defined, raised, oval, firm, yellowish area about 1 centimeter in diameter at the site of the previous operation. In the center was a depressed puckered scar. There was no pain or soreness in the tongue, and the increased firmness of the raised area was no doubt due to the fibrosis resulting from the action of the radon seeds. As an additional measure of precaution, six more gold radon seeds of 1 millicurie each were embedded concentrically about the site of the lesion. Since this time there have been several severe attacks of pain in the tongue and neck, for which deep roentgen ray therapy was given. There has been no pain since last October nor any evidence of recurrence of the neoplasm.

A very interesting feature of this last case is the fact that the metastases were noted long (3 years) before the primary lesion. Since the whole process was of slow development, it must be inferred that the primary lesion was present for perhaps at least 4 years; and, since malignant mixed tumors usually have a period of benign growth before malignant degeneration, it is possible that the primary tumor was present for a considerable length of time before its discovery.

The number of cases of mixed tumor in the tongue summarized is small but nevertheless permits analysis for comparison with the large series of mixed tumors of the salivary glands reviewed by Heinecke. Cases 4 to 14 of this series were adults, the youngest of whom was 24, and the oldest 78 years of age. Four patients, or 36 per cent, were in the third decade; 6 were females, 5 were males; 3, or 28 per cent, were definitely malignant. In Heinecke's series (360 cases) the youngest patient was an infant born with parotid mixed tumor; the oldest was in the seventh decade. Thirty per cent of the cases were in the third decade. Males and females were equally affected. According to this author the exact incidence of malignancy in mixed tumors is difficult to determine since, because of their complex structure, a definite diagnosis of malignancy cannot be made from study of microscopic preparations alone. Kuettner, in a series of 56 submaxillary mixed tumors, states that 28 per cent were malignant, and Wood, in a series reviewed from the literature, states that about "25 per cent undergo changes which express themselves in a clinically malignant course." Thus, in behavior, mixed tumors of the tongue resemble closely mixed tumors of the salivary glands.

The diagnosis of mixed tumor of the tongue is difficult clinically because of the rarity of the condition and because there is no constant clinical picture. As shown on physical examination, these tumors may have all the characteristics of a slowly growing encapsulated benign neoplasm or may resemble malignant tumors with infiltration of surrounding tissue and metastases. The symptomatology of mixed tumor of the tongue is also extremely variable and depends upon the location of the tumor and its size. In some instances only its presence was noted by the patient; on the other hand, pain, impairment of speech and deglutition, and even hæmoptysis were the complaints.

Of the cases reported above, 7 occurred at the base of the tongue. It is not uncommon to find in this region aberrant masses of thyroid tissue, exhibiting immature structure, or remnants of the thyroglossal duct. What relation, if any, these structures may have to the origin of mixed tumors in the tongue cannot be definitely stated. Furthermore, there occur in the mucosa of the buccal cavity numerous small tubulo-alveolar mucous and serous (salivary) glands. The possibility of origin of mixed tumors from these glands (glandulæ lingualis), which are also present in the tongue, must be borne in mind.

The treatment of mixed tumors of the tongue in the cases reviewed was excision. Subsequent histories were not available in most of these reports. In the last case reported above, radium therapy combined with excision of the primary lesion and metastases has afforded, until the present at least, satisfactory results. The facts that malignant mixed tumors do not as a rule grow very rapidly and that they tend to produce only regional metastases, permit a more or less favorable prognosis for combined surgical and roentgen therapy in cases that have not progressed too far.

SUMMARY

1. Mixed tumors of the tongue and of the sublingual gland are very rare. In a review of the literature the author found but 2 re-

ported cases of mixed tumor in the sublingual gland and 10 in the tongue.

2. A case of mixed tumor, type cylindroma, of the sublingual gland is reported. This neoplasm was present for 19 years. Apparently benign at first, it finally became malignant, causing extensive local destruction and producing metastases in the lungs and pleura.

3. A case of slowly growing malignant mixed tumor of the tongue of several years' duration, with metastases to the regional lymph nodes, is reported. Combined surgical (excision) and radium therapy appears to have eradicated the process.

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ANATOMICAL CONSIDERATION OF THE ULCER BEARING AREA (LESSER CURVATURE OF THE STOMACH, PYLORUS, AND FIRST PART OF THE DUODENUM)

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IN comparing statistics on ulcers in the old and new textbooks we find a marked difference, for the percentage of cases is far greater in the recently published volumes. This, however, does not mean that ulcer has become more prevalent but it does show the great strides that have been made in the study of the disease.

Formerly, the general practitioner diagnosed it incorrectly as indigestion, for there were comparatively few methods of study. In recent years, with the aid of the X-ray which has made possible the study of both the normal and the pathological stomach, with the development of surgery to make the stomach and intestines available for direct study of the pathology of the ulcer, and with the findings from physiological experiments on the normal and pathological stomach, there have been radical changes in the conception of the production and development of ulcer. We have discovered ulcer to be a common occurrence and consequently statistics now show a great increase in the percentage of its frequency.

The question then arises as to whether ulcers occur in selected regions of the stomach and duodenum. We can determine this by investigating the findings from four different sources, viz.: (1) the necropsy findings, (2) the statistics of surgery, (3) the experimental studies, and (4) the X-ray findings.

NECROPSY FINDINGS

In numerous large hospitals throughout the world, particularly in government and city hospitals, it is the custom to make necropsies on the patients who succumb there. Following are some of the statistics that have been compiled from the necropsies in these institutions.

Brinton found that of 205 ulcers 42 per cent were on posterior surface and 26.8 per cent on lesser curvature. Fenwick's statistics show that in an analysis of 1,015 cases of gastric ulcers nearly 76 per cent were situated in the pyloric region of the stomach near the lesser curvature and on its posterior surface. Collins, in a study of 262 cases, found the ulcer in the first portion of the duodenum in 242 cases. In Perry and Shaw's series of 149 cases, there were 123 in which the ulcer was in the first part of the duodenum. Welch's figures show that 78 per cent of all chronic ulcers occupy the lesser curvature, the posterior wall, and the region about the pylorus. Martin's combined statistics of 2,000 cases and the figures given by most later pathologists differ from Brinton's in placing the largest group (35 per cent) on the lesser curvature and giving the posterior wall (with 28 per cent) the position of next greatest frequency. Ruthmeyer found 31 per cent on the small curvature, 21 per cent on the posterior wall, and 13 per cent in the pyloric region. Bennett states that fully three-fourths of all chronic peptic ulcers occur in proximity to the pyloric canal but that, if more recent ulcers be considered in a group, the larger number occurs in the stomach, especially in the region of the lesser curvature. Bolton notes that ulcers of the duodenum occur, with remarkable constancy, in the anterior wall of the organ and in 95 per cent of these cases in the first part of the duodenum. The ulcers are usually found on the anterior or posterior surface of the duodenal cap. Clairmont has observed 73 per cent on the posterior wall and 60 per cent on the anterior. Bassler says that, after considering the relative numbers of cases in the four portions of the duodenum, it can be definitely stated that the nearer the pylorus the greater is the percentage of ulcers. Practically all of those in the first portion extend to within ¾ inch of the pyloric sphincter and the deepest portion of the ulcer is just outside the pylorus, where the acid chyme readily affects the intestinal mucosa.

SURGICAL STATISTICS

During the past 10 years great progress has been made in the surgical treatment of gastro-intestinal diseases, particularly of ulcers of the stomach and the duodenum. In place of posterior gastro-enterostomy, the old type of operation for these ulcers, surgeons now use partial gastrectomy, a most radical operation, which involves the removal of a large part of the stomach and the ulcer bearing area. This affords a great opportunity for finding the exact location of the ulcer.

There have been many noted surgeons who have collected from their operations statistics concerning the position of ulcers in the pyloric region and the first part of the duodenum, but we shall mention only a few of these surgeons. Moynihan in his book, "Duodenal Ulcer," states that in at least 95 per cent of the total number of cases the ulcer lies within 1½ inches of the pylorus. Others, among them Mayo, Balfour, Haberer, and Strauss, also have noted in their operations that most of the ulcers occur in the pyloric region of the stomach and in the first part of the duodenum.

EXPERIMENTAL STUDIES

During the past 5 or 10 years, many medical schools and hospitals have carried on experimental studies to produce ulcers and to find the cause of this disease. Rosenow showed that ulcer of the stomach is often associated with a streptococcus infection in the ulcerated area; that foci of infection, such as in tonsils and teeth, harbor the streptococcus and predispose to ulcer; and that the streptococcus isolated from the ulcer and from the distant focus has elective affinity for the stomach, producing hæmorrhage and ulcer on intravenous injection. He injected many dogs and rabbits and 91 per cent of them developed lesions of the stomach, mostly in the lesser curvature. Of 168 animals injected with 37 strains of streptococci from patients with gastric ulcer, 68 per cent had lesions of the stomach particularly on the lower curvature.

Nakamura injected 28 rabbits with living streptococcus isolated from the tonsils of a male patient with ulcer, and 23 of these rabbits developed lesions of the stomach, mostly in the pyloric region. The streptococcus which had been injected was later found to be present in those regions where the ulcers had formed.

Haden, in conducting a study of 12 cases of peptic ulcer in the attempt to establish a possible causal relation between dental infection and ulcer, made cultures from foci of infection in dental areas and injected 45 rabbits intravenously. At necropsy 53 per cent of these rabbits showed gross lesions on lesser curvature and first part of the duodenum.

Boldyreff, through experiments, found that the high acidity of the gastric juice as it flows from the glands is lowered to normal ranges automatically by the constant regurgitant influx of duodenal juice into the stomach. This duodenal fluid is composed of pancreatic juice, bile, and succus intericus. Neutralization of gastric acidity by this regurgitating fluid is an important part of the digestion. On this basis, Mann and Williamson, also Morton, did the following experiments to show the relation between the acid and the production of ulcers.

Experiment 1. This operation was called a surgical duodenal drainage and the operative procedure was as follows: The pylorus was severed and the distal end closed; the first part of the jejunum was severed and the proximal end closed. End-to-end anastomosis was then made between the proximal end of the severed pylorus and the distal end of the severed jejunum, and the continuity of the gastro-intestinal tract was thus restored. Then, to form an outlet for the closed segment of gut, consisting of the duodenum and a small part of the first portion of the jejunum, a side-to-side anastomosis was made between this closed portion of jejunum and the lower ileum about 25 centimeters proximal to the ileocæcal valve. The result of this was to substitute the jejunum functionally and anatomically for the duodenum. Thus the secretion poured into the duodenum was drained far down into the ileum and the gastric contents flowed into the jejunum without being mixed with the duodenal contents. Surgical duodenal drainage, shunting the alkali in the duodenum to the ileum and precluding the possibility of regurgitation of alkali as far as the region of the pylorus, caused an acid-alkali imbalance in the stomach and the intestine into which it emptied by the practically complete removal of alkali from the region: The result of this experiment was that in 100 per cent of the cases peptic ulcers developed in the jejunum, which took the place of the duodenum, just distal to the suture line. When the gastric contents were expelled from the stomach into the jejunum without being mixed with the duodenal contents, the ulcers developed at the site where the

gastric contents can impinge directly and probably with great force upon the intestinal mucosa.

Experiment 2. Areas of gastric mucosa were excised following the operation for surgical duodenal drainage. Healing of the denuded areas was always delayed but the delay was most marked in areas on the lesser curvature, and in more than 50 per cent of the cases chronic peptic ulcers developed there.

Experiment 3. (a) Twenty-one experiments were done in which patches of jejunum were transplanted into the wall of the stomach at various points and observed for long periods and it was found that ulcers developed in the lesser curvature of the stomach. (b) In 13 of these same experiments surgical duodenal drainage was instituted after the patches had been normal from 80 to 419 days. Ulcers developed in the lesser curvature near the pylorus.

Experiment 4. Another experiment was done in which the common bile ducts and pancreatic ducts were transplanted into the terminal ileum. Thus the alkali that should have flowed into the first part of the duodenum went into the lower part of the intestines and the first part of the duodenum had no alkali to neutralize the acid that flowed in from the stomach. The result was that later ulcers developed in the duodenum just beyond the pylorus.

Results. These experiments show that there is a definite tendency toward the formation of peptic ulcer on the lesser curvature of the stomach. Areas on the greater curvature healed completely while areas on the lesser curvature healed very sluggishly and went on to chronic peptic ulceration in as high as 62.5 per cent of prolonged experiments. Peptic ulcer of the jejunum formed following surgical duodenal drainage in almost 100 per cent of the cases and, when areas of gastric mucosa were excised following the operation for surgical duodenal drainage, healing of the denuded areas was always delayed and chronic ulcers formed.

X-RAY FINDINGS

For the past 15 years there has been a marked advancement in the X-ray diagnosis of gastro-intestinal diseases, particularly of ulcers of the stomach and duodenum. The roentgenologists, Schlessinger, Assman, Knox, Groedel, and Carman, in their writings based on certain accepted direct and indirect signs by which the diagnosis of ulcers are made, state that most ulcers occur in the lesser curvature of the stomach and the first part of the duodenum.

As shown above, it can now be definitely stated that ulcers of the stomach in the greater percentage of cases are located on the lesser curvature of the stomach in the pylorus and the first part of the duodenum (Fig. 1). The question naturally arises as to whether there

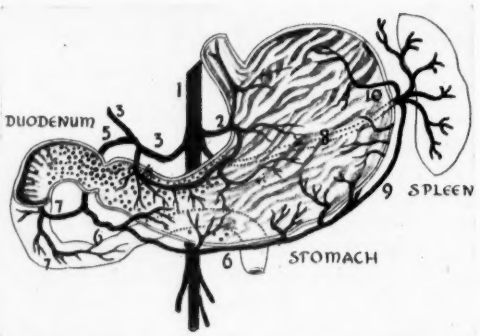

Fig. 1. Diagram of the stomach and duodenum, showing *A*, The mucosal folds in the fundus and greater curvature, convoluted and redundant, while in the pylorus they are stretched and parallel. *B*, Relation of arterial blood supply to the stomach. *1*, cœliac trunk; *2*, left gastric (coronary); *3*, hepatic; *4*, right gastric; *5*, gastroduodenal; *6*, right gastro-epiploic; *7*, superior pancreatico duodenal; *8*, splenic (dotted line behind stomach); *9*, left gastro-epiploic; *10*, vasa brevia. *C*, Distribution and frequency of ulcers in the stomach and duodenum, represented by black dots.

is any histological and anatomical explanation therefor. It is expedient first to review the more important anatomical features of the stomach, including its blood supply, and also the more important functional phenomena.

MUSCULAR STRUCTURE OF THE STOMACH

Generally speaking, there are three layers in the muscular coat of the stomach—an outer longitudinal, a middle circular, and an inner set of fibers.

The longitudinal fibers. The longitudinal fibers are continuous with those of the œsophagus and are massed along the lesser and greater curvatures. Those which pass over the greater curvature become thin and spread over the fundus. In the region of the gastric tube and the pyloric part the longitudinal fibers of the greater curvature are well developed. In the region of the pyloric canal the longitudinal fibers form a complete coat rather thicker along the greater than along the lesser curvature. The greater part of the longitudinal fibers passes into the circular coat of the pyloric canal to terminate among its fibers, some reaching the submucosa.

The circular fibers. The circular fibers are most thickly massed in the pyloric part and in the gastric tube. They become much less nu-

merous toward the cardiac sac, on which they thin out and disappear. The circular fibers of the pyloric sphincter are not continuous with those of the duodenum. The latter are separated from the former by a hiatus of connective tissue, which may in the adult be 3 millimeters thick. The circular fibers of the pyloric canal are much more numerous than those of the pyloric vestibule along the greater curvature. Hence the increase in thickness is well marked at the sulcus intermedius.

The internal layer fibers. The internal layer of oblique muscle fibers forms a tænia on either side of the lesser curvature. The two tæniæ blend with each other round the left side of the cardiac orifice, to present a horseshoe-shaped appearance, the arms of the horseshoe lying parallel to and above the lesser curvature as far as the incisura angularis. The tæniæ, if followed toward the pyloric part, are found to give off fibers which bend toward the greater curvature at an acute angle and mingle with the fibers of the circular coat. At the level of the incisura angularis the tæniæ have disappeared, the whole of their fibers having merged with the circular fibers. The internal layer is entirely limited to the cardiac part of the stomach.

The combination of these different layers results in the formation of a muscular sac which has its distal or pyloric portion formed of a strong and powerful wall of well developed muscular fibers. In the rest of the sac the wall is thinner and the muscular development much less pronounced.

SUBMUCOSA

The submucosa in the stomach consists of a lax connective tissue which unites the muscular coat with the mucosa. The submucosa is readily stripped off the muscular coat but is quite adherent to the mucosa, with which its tissue is continuous. The vessels and nerves run in the bed formed by the submucosa before they break up to enter the mucosa. The laxity of the mucosa enables it to become rugous when the muscular coat contracts. In the pyloric region the muscular fibers are bulkier and more separated from each other than in the cardiac portion of the stomach. Hence the tissue of the submucosa penetrates farther between the fibers of the muscularis in the pars pylorica than in the rest of the organ. The submucous connective tissue even forms a barrier between the circular fibers of the pyloric and duodenal muscular coats. The evidence seems to indicate that, along the gastric pathway, in the vestibule, and in the pyloric canal, the submucosa is firmer in texture and the muscularis mucosæ better developed than in the other parts of the stomach.

MUCOSA

The mucous membrane of the stomach consists of an epithelium of cylindrical cells, a basement membrane, a corium into which the glands extend, and double muscular mucosæ. The inner layer is circular and the outer is a longitudinal one which separates the mucous membrane from the submucous coat. The tissues of the mucosa and submucosa are, however, continuous. The mucosa is thinnest in the region of the fundus, where it is only 5 millimeters thick. It becomes progressively thicker from cardia to pylorus, measuring 0.5 to 1.5 millimeters in depth at former situation and 2.2 millimeters at latter. The pyloric mucosa is closely attached and relatively smooth.

Along the lesser curvature are found four well marked longitudinal mucosal folds, which extend through the zone of the isthmus, spreading out in fan-like shape into the pyloric canal and forming the gastric pathway, which is sparsely supplied with widely separated folds. The convolutions of the greater curvature are, on the contrary, very numerous, freely movable, and without definite arrangement. The line of demarcation between the mucous membrane of the gastric pathway and that of the corpus is indicated by the course of the oblique fibers, which, according to Bauer, act as a kind of sphincter between the corpus on the one side and the gastric "street" and pyloric canal on the other. A further point of difference is that, during contraction of the stomach, the longitudinal mucosal folds of the street are stretched and under tension, especially in the region of the isthmus, while the mucosa of the corpus becomes redundant and convoluted (Fig. 1).

Rugæ are found in the mucous membrane of the contracted stomach. The rugæ are, as

a rule, stellate in the cardiac portion and parallel with the long axis in the pyloric part.

The upper portion of the stomach is richly supplied with mucosal folds, which in case of erosion overfold and overlie the affected part with the result that rapid repair ensues. But should any lesion or erosion occur in a portion sparsely supplied, as is the gastric pathway, there is no protection and there is active transit of food and infectious material over that area. Under such circumstances healing becomes especially difficult and ultimately an ulcer will develop.

GLANDS

The mucous membrane of the stomach contains two distinct varieties of glands. These varieties differ chiefly in that one exhibits only a single type of cell in the lining of the basement membrane, while in the other two distinct types of cells are present. On account of their distribution in the stomach these are generally known as pyloric and fundal glands.

Pyloric glands are deeper and larger and are lined entirely by cells of the chief or central type, which secrete pepsinogen or the proferment of rennin. Each of these cells consists of two or three short, wavy tubules opening into a common duct. The tubes are lined with finely granular cubical cells, while the ducts have more or less columnar cells. Acid forming or oxyntic cells are absent.

Fundic glands are by far the most numerous. They occur throughout the whole body of the stomach with the exception of the cardiac and pyloric regions. They consist of tubes lined with two types of secreting cells. Projecting from the basement membrane toward the lumen of the duct, there is a continuous lining of granular polyhedral cells, known as central cells. Between these cells and the basement membrane are large oval cells, opaque and granular in appearance, known as parietal or oxyntic cells. It is generally believed that these secrete the hydrochloric acid of the gastric juice; presumably the central cells of all the glands secrete pepsin and other digestive ferments.

According to Bensley and Harvey, the acid forming parietal cells do not produce actual hydrochloric acid but secrete an alkaline forerunner of it, which is changed by reaction outside the cells.

Beginning at the cardio-œsophageal junction there is a special form of gland, known as the cardiac type, and it has no pepsin secreting function. In that zone the oxyntic or acid cells are few in number and of medium size, but about 2 centimeters from the œsophageal orifice on the lesser curvature the cells increase in number and are located mainly in the fundal portion of the glands. The cells become fairly numerous toward the cardiopyloric junction; they also increase somewhat in size and become more numerous in the necks of the glands. At the cardiopyloric junction there is a fairly sharp reduction in the number of oxyntic cells and only a few scattered acid forming cells are seen beyond the junction. The position of the junction is 60.07 per cent of the distance from the cardiac orifice.

Beginning at the cardio-œsophageal junction, the dorsal or greater curvature shows the cardiac glands numerous and the oxyntic cells few in number. Farther on, the acid forming cells are at first few and scattered. They are located mainly in the necks of the glands. From this region to the junction there are alternating decreases and increases in the number of acid forming cells and a sudden cessation at the junction. The junction is 83.57 per cent of the distance from the cardiac orifice.

ARTERIAL SUPPLY

Cœliac trunk
- I. Left gastric (coronary)
- II. Hepatic
  - Right gastric
  - Gastroduodenal
    - Right gastro-epiploic
    - Superior pancreaticoduodenal
- III. Splenic
  - Vasa brevia
  - Left gastro-epiploic

The arterial supply of the stomach comes from the cœliac trunk. This short wide vessel lies behind the omental bursa and runs forward for 12 millimeters between the condate lobe of the liver above and the upper border of the pancreas and the splenic vein below. It terminates by dividing into (1) the left gastric artery, (2) the hepatic artery, and (3) the splenic artery (Fig. 1).

The left gastric artery (coronary) runs upward and to the left behind the omental bursa and, passing forward in the left gastric pancreatic fold, reaches the lesser curvature adjacent to the cardia. The artery then runs along the lesser curvature, close to the stomach wall, and anastomoses with the right gastric (pyloric) branch of the hepatic artery. It gives off branches to the lower gullet and to both surfaces of the stomach. Many of these pierce the circular musculature of the gastric pathway and form a plexus in the submucosa.

The hepatic artery runs along the upper border of the head of the pancreas between the layers of the right gastropancreatic fold of the peritoneum to reach the first part of the duodenum. From there the artery passes upward between the layers of the hepatoduodenal ligament to reach the liver. The arterial branches to the stomach are the right gastric and the gastroduodenal vessels.

The right gastric artery arises from the hepatic trunk in the gastrohepatic ligament above the pylorus, to which it passes first, then, turning to the left, supplies both sides of the pyloric part of the stomach, and anastomoses with the left gastric artery in the region of the incisura angularis. Like the left gastric vessel, it is closely applied to the stomach wall.

The gastroduodenal artery descends behind the first part of the duodenum, on the under aspect of which it divides into the right gastro-epiploic and the superior pancreaticoduodenal vessels.

The right gastro-epiploic artery passes to the left behind the first part of the duodenum and above the head of the pancreas to reach the gastrocolic ligament (part of the great omentum), between the layers of which it runs parallel to, but some distance from, the greater curvature, to supply the pyloric canal and vestibule with branches. It anastomoses with the left gastro-epiploic vessel near the junction of the gastric tube with the pyloric vestibule.

The splenic artery, which is large and tortuous, passes to the left behind the omental bursa along the upper spleen, running between the layers of the lienorenal ligaments, and its branches to the stomach pass onward between the layers of the gastrosplenic ligament. These are the vasa brevia, which supply the fundus proper and adjacent parts of the cardiac sac and the left gastro-epiploic, which gives off branches to the gastric tube and adjacent parts of the cardiac sac.

There are two arterial circles, which form along the lesser and greater curvature of the stomach. The smaller circle, along the lesser curvature, is formed by the right gastric, a branch of the hepatic artery, and the left gastric, a branch of the cœliac trunk, which anastomose in the region of the incisura angularis. The larger circle, along the greater curvature, is formed by the right gastro-epiploic, a branch of the gastroduodenal artery, and the left gastro-epiploic, a branch of the splenic artery, which anastomose near the junction of the gastric tube, with the pyloric vestibule. The branches of the arteries mentioned leave the greater curvature and quickly penetrate the stomach wall in the fundus region, where they ramify.

There are three important points to be noted in considering the arterial blood supply of the stomach.

1. The upper part of the stomach (fundus) receives its blood supply from three different branches—namely, the left gastric, the left gastro-epiploic, and the vasa brevia—whereas the lower part (pylorus) is supplied by two branches only—the right gastric and the right gastro-epiploic.

2. The fundus receives its blood supply from the main source through two different channels and, in case of a disturbance in one, the deficiency can be supplied by the other. The pylorus, however, receives its blood supply from the same source but through only one channel (the hepatic), and consequently there is no other possible route by which the reserve blood supply may be tapped in case of an emergency.

The fundus, through the left gastric artery, receives a direct blood supply from the main source, which is the cœliac trunk, and therefore the amount of blood supplied to this region is greater. The blood which supplies the other regions of the fundus, through the left gastric epiploic and the vasa brevia, must first pass the splenic before reaching these parts

and the distance to be transversed from the main source is therefore greater. The pylorus, on the other hand, receives its blood supply through the right gastric and the right gastric epiploic. Before reaching these arteries, the blood must pass the hepatic artery and branches of the gastroduodenal arteries, the distance, therefore, being greater and the blood flow per volume much less in this region.

The arteries of the submucosa, in the pyloric region of the lower lesser curvature of the stomach, are practically terminal vessels and are relatively sparsely distributed, giving a limited blood supply to this area. They are tortuous, anastomose infrequently, and are subject to powerful and repeated forcible constrictions by numerous interlacing, intricate, and frequently contracting muscle bundles. These constrictions tend to interfere with the circulation and, moreover, the terminal vessels are subject to the same tendency to circulatory interference by reason of easy blocking as are the terminal vessels in the brain or kidney and are especially liable to harbor the foci of anæmia.

In his recent study of the anatomical arrangement of the arteries of the stomach, Berlet has proved that the arteries in this region are predisposed to circulatory disturbances and are deficient in their ability to establish an adequate collateral circulation.

The arteries of the fundal wall are not terminal, as in the pyloric region, and are less tortuous than the arteries there but, on the contrary, anastomose more freely and, on account of the scarcity of interlacing muscle bundles around the arteries, are less subject to constrictions and blocking. The muscular wall of the fundus, which is much thinner than that of the pylorus, serves as a reservoir for the food, rather than taking an important part in the mechanical action of the stomach. Consequently, there is less muscular pressure on the arteries which supply the fundus than on the pyloric arteries and less danger of interference with the circulation of the former than of the latter.

A number of experiments were undertaken to prove that there is a difference in the blood supply to the pyloric and fundic regions and, on ligation in the regions of the left gastro-epiploic arteries, there was no recognizable influence on the fundic mucosæ, because they anastomosed with other sources, whereas ligations in the right gastric or right gastro-epiploic or in both vessels led to localized nutritional disturbances.

DUODENUM

As previously mentioned, most ulcers are located in the first portion of the duodenum (Fig. 1), the place of predilection for ulcers in the duodenum being, as in the case of the stomach, close to or upon the lesser curvature.

The explanation of such a phenomenon can probably be found in the anatomical and histological features of the duodenum. The first portion of the duodenum (bulbus duodeni), from a structural point of view, stands out as an unique organ; and, histologically, stands between the stomach and the small intestine and possesses some of the characteristics of both.

The muscular structure of the duodenum is somewhat similar to that of the stomach. The muscular coat of the duodenum consists of two layers: the external layer, made up of longitudinal muscles, and the internal layer, of circular muscles. The longitudinal muscular coat completely envelops the duodenum and shows marked irregularities in thickness in its different portions. Its greatest development and thickness is along the border of the lesser curvature of the stomach, in contrast to other regions of the duodenum, where the muscle bundles are so thin that the circular fibers can be seen through them. The longitudinal muscle fibers form a band, along the lesser curvature border of the duodenum, which varies in width from 1 to 2¼ centimeters. These fibers penetrate the pyloric sphincter and intertwine with terminal fibers of the longitudinal muscles of the stomach at the sphincteric ring except on the greater curvature side of the duodenum. Some also enter into the duodenohepatic ligament which is attached at the upper border of the duodenum and forms the only suspension mechanism of the duodenal bulb.

The circular muscle fibers originate in the lesser curvature border of the duodenum and

run in somewhat arc-like fashion to the longitudinal fibers. These circular fibers start on a plane internal to that of the pyloric sphincter. According to Ochsner, the circular muscular coat has sphincteric bands of varying widths and at varying sites in the organ. Their most common position is 3 to 10 centimeters distal to the common bile duct.

The mucosa of the duodenum is thrown into large transverse raised folds, the valvulæ conniventes of the intestinal tract. These are not present in the first portion of the duodenum, where the mucosa is smooth, but begin about the junction of the first and second portions as small folds, increasing in size until approximately the full size and height of these folds is seen in the upper part of the small intestine (jejunum). The submucosa is similar to the submucosa of the stomach and needs no comment.

There are certain glands peculiar to the duodenum, known as Brunner's glands. They are most numerous in the first part of the organ and in the second part as far as the common bile duct. Beyond this point they decrease in number and finally cease at or about the duodenojejunal junction. Their final distal limit forms, therefore, a very useful indication of the termination of the duodenum.

The arterial supply of the duodenum comes partly from the cœliac axis vessel via the superior pancreaticoduodenal branch of the gastroduodenal artery, which itself arises from the hepatic trunk, and partly from the superior mesenteric artery through the inferior pancreaticoduodenal branch. These two vessels form a loop around the head of the pancreas. Wilkie believes that the first part of the duodenum does not get its blood supply direct from the main trunk of the superior pancreaticoduodenal vessel but through a branch which arises from the proximal part of the gastroduodenal artery. This branch was called by Wilkie the supraduodenal vessel and it presents no anastomosis with neighboring arteries. The little communication it might have with the pyloric or duodenal branch of the right gastro-epiploic artery is never very free. Mayo has drawn attention to the anæmic spot which often appears on the ventral wall of the first part of the duodenum if the gut be stretched by traction on the pylorus. It is therefore clearly seen that, as Wilkie believes, the blood supply to the first portion of the duodenum is easily disturbed.

MECHANICAL ACTIVITY OF THE STOMACH

The human stomach is divided into two parts, namely, the pylorus and the fundus. The muscular pyloric part is burdened with the food, mixes it thoroughly with the acid gastric juice, and breaks it down by muscular action. It bears the brunt of the trauma administered to the gastric mucosa when the stomach is emptied by mechanical contraction. The stomach impels digested material most directly along the lesser curvature to expel it through the pylorus; therefore the lines of force exerted by the contracting musculature always tend to converge along the lesser curvature. The muscles in this part of the stomach are always active and as a result they are bulkier and heavier than in the fundus. Peristalsis, which usually starts in the middle of the stomach, is most active in this region and the blood vessels in the pylorus are constantly subject to a circulatory disturbance due to the muscular contractions.

The fundus, on the other hand, is less muscular than the pylorus, has very little mechanical activity, and acts merely as a reservoir to contain the food. The acid secretion is supplied by the oxyntic glands which are most numerous in this region.

The food, after it is digested, is expelled by the muscular activity of the pylorus through the duodenum into the jejunum. It impinges with full force upon the mucosa of the first part of the duodenum, causing great tension there, which gradually passes into the other parts of the duodenum. With each expulsion of food from the pylorus, a certain amount of acid passes through the sphincter into the duodenum, thus affecting the mucosa of the first part, which is constantly imbedded in the alkaline secretion.

SUMMARY

There are undoubtedly sufficient anatomical reasons to explain the existence of ulcers in the area which comprises the lesser curvature of the stomach, the pylorus, and the first

part of the duodenum. I shall give a summary of the peculiarities of this area, as it compares with other parts of the stomach and duodenum.

1. The pyloric wall is firm, strong, and well developed, and is composed of thick longitudinal and circular muscles, while in the fundus the walls are thinner. The internal layer of oblique fibers is limited entirely to the cardiac part of the stomach.

2. The submucosa is firmer in texture, bulkier, and better developed in the pyloric region than in other parts of the stomach. It is adherent to the mucosa in this region but is more lax in the fundus, where it enables the mucosa to become more convoluted when the muscular coat contracts.

3. The mucosa in the pyloric region is closely attached, smooth, and thick, while in the fundus it is thin. The pylorus is sparsely supplied with folds and the convolutions are numerous, freely movable, and without definite arrangement. The longitudinal mucosal folds in the lesser curvature are stretched and under tension, while in the fundus they become redundant and convoluted.

4. Rugæ are found in the mucous membrane of the contracted stomach. The rugæ are, as a rule, stellate in the cardiac portion and parallel to the long axis in the pyloric part.

5. The pylorus is provided with the pyloric glands only, while the fundus possesses oxyntic cells, which secrete acid. The central cells, which form the pepsin and other digestive ferments, also are in the fundus. The acid forming cells extend for approximately 60.7 per cent of the distance from the cardia to the pylorus, along the lesser curvature, and 83 per cent of the distance between the orifices along the greater curvature.

6. (a) The fundus receives its blood supply from the main source through three different branches, while the pylorus is supplied from the same source through two branches only. (b) The fundus is supplied with blood direct from the main source and one primary branch, hence the amount of blood per volume is greater there than in the pylorus, which is supplied only by primary and secondary branches, the distance which they traverse being longer, and the amount of blood per volume much less. (c) The arteries in the pylorus are practically terminal vessels, sparsely distributed and tortuous. They anastomose infrequently and are subject to powerful constrictions by numerous interlacing, frequently contracting muscle bundles. The arteries in the fundus are not terminal, are less tortuous, anastomose more freely, and, on account of the scarcity of interlacing muscle bundles, are less subject to constrictions.

7. The muscles of the pylorus are bulky and heavy, for it bears the burden of the food, mixes it with the acid gastric juice, and breaks it down by muscular action. The fundus serves merely as a reservoir to contain the food and does not take an important part in the mechanical activity of the stomach, hence its muscles are much thinner than those of the pylorus.

8. The muscles are thicker and bulkier in the first part of the duodenum than in any other part, and the sphincteric rings and mucosal folds, which are lacking elsewhere, are located in this region. Glands known as Brunner's glands are most numerous in this part of the duodenum.

9. The first part of the duodenum is under a greater tension than the remainder of it, because of the force exerted by the food which is expelled from the pylorus. The mucosa in this region, which is constantly imbedded in the alkaline secretion, is frequently damaged by the mixed acid food which is expelled from the stomach.

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PERI-ARTERIAL SYMPATHECTOMY IN CIRCULATORY DISORDERS OF THE EXTREMITIES

Report of Cases

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IN 1924, when I presented my first paper[1] on peri-arterial sympathectomy before the Clinical Congress of the American College of Surgeons, it seemed that a new era had dawned with regard to the relief of those circulatory disorders of the extremities that tend to eventuate in gangrene. Leriche, sponsor of the procedure, had given glowing reports of his successes and other foreign surgeons had had their triumphs, so that it did not surprise me when certain of my operative trials gave the much sought relief. The report referred to comprised 9 cases and contained a detailed description of the operation, together with appropriate drawings.

I mention this latter because certain of the surgeons who undertook to do the operation had little or no satisfaction with it and as a result the procedure in this country has found scant favor. It may be that too much has been expected, but one cannot help but wonder whether the details of the operation have been followed out faithfully and efficiently. Blood vessel surgery, to be successful, requires a modicum at least of special training and the removal of the adventitial coat of a major artery that is pulsating cannot be regarded as but another operation in the long list of a busy general surgeon's morning work.

Then, too, the question naturally arises as to the character of case in which the operation has been done. For unless one has some special knowledge of vascular conditions that affect locomotion he is more prone to suggest sympathectomy in a given case than is the surgeon who has such knowledge. Patients quite naturally do not relish the idea of losing their limbs and, as has often been remarked, amputation is but a confession of failure. Even so, it is better surgery to remove a member when truly indicated than to attempt a reconstructive operation which, by every rule we have to guide us, is doomed to failure. Furthermore, it throws no slight on a procedure that under favorable circumstances still seems to have much to commend it.

My own series of cases in which sympathectomy has been done has now grown from 9 to 28.[2] It could have been much larger, but from the beginning I laid down certain indications for the operation and in so far as was possible adhered to them religiously. Dead tissue cannot be restored to life and morphine addicts practically never get relief from this operation or any other save amputation. Indeed, the most serious contra-indication of all is the morphine habit and unless I can get my patients cured of it I absolutely refuse to do a sympathectomy on them. Certain of my early non-successes were directly attributable to a failure to recognize clearly the importance of opium as a contra-indication.

In one regard, however, I have changed my mind completely. I formerly laid much stress on the state of the arterial circulation. It is of importance, naturally, and generally speaking, the better the arterial supply the better the chances of success. Certainly, the patient who still has pulsation in the popliteal artery would seem to be better off than the one who has not. So, too, the presence of pulsation in the femoral artery is more heartening than is absence of it. But I no longer regard as hopeless those patients whose entire arterial system—femoral, popliteal, and on down—is absolutely blocked. Interesting, too, is the way this change of opinion came about. Upon several occasions I did an exploration just to be absolutely sure that the femoral artery was blocked and in each instance when the pre-operative diagnosis proved to be correct nothing further was done—except in 1 case. In that case, for some inexplicable reason, I did the regular sympathectomy anyhow—and was rewarded with tempo-

[1] Bernheim, Bertram M. Peri-arterial sympathectomy; indications for its use in circulatory diseases of the extremities. Surg., Gynec. & Obst., June, 1925, xl, 828–835.

[2] Really 31, but 3 of them are too recent to be included in this report.

rary, if not permanent, relief of pain and improvement in the general condition of the leg. So much improvement was gained that I have since carried out the operation in every detail upon several similar patients and one of them is all but the most brilliant success in the series.

Nor do I hold with those who consider the operation applicable to Raynaud's disease only. Perhaps the most successful case I have had was that of a man 68 years old who had a generalized arteriosclerosis and whose femoral artery was typical of that disease. And in 3 other highly satisfactory cases the patients had and still have the most typical thrombo-angiitis one could wish to see, including superficial migrating phlebitis. Each case must be considered as an entity and the decision to operate or not to operate had best depend solely on the physical findings, quite regardless of the clinical or pathological diagnosis. It has been my feeling throughout the years that all vascular diseases that affect the vessels of the extremities are so closely related as to be really indistinguishable except in their early stages. However they may begin and however different their incipient signs and symptoms are, they all tend to obstruction of main blood channels by obliterative processes of one form or another, they all have pain, they all tend to ulceration, they all point toward ultimate gangrene, and they reach the end unless a collateral circulation adequate to nourish the tissues is established.

I lay great stress on the blood pressure and have made two contributions on the subject.[1] For some unknown reason a low pressure—oftentimes a very low pressure—is an almost constant finding in those who have serious disturbance of their peripheral vascular system. And the lower the pressure the worse the prognosis. It is a simple matter of mechanics and is not difficult to understand. If one has not a pressure of some force back of his blood stream, it is idle to hope for the development of those circuitous routes of blood flow that go under the generalized term of collateral circulation. Rarely does a real hypertension patient have a gangrene or even a threatened gangrene. Such patients may have a gangrene after a cardiac break, and I have seen several such, but it is usually after a break. But if compensation can be restored without too great delay, and maintained, gangrene will be averted. If it cannot, gangrene will supervene. In other words, any circulatory derangement of the extremities in the presence of a low blood pressure is most dangerous. This cannot be emphasized too much.

But this blood pressure feature is of particular importance to me because I look upon periarterial sympathectomy more in the light of a "tiding-over affair." It is true that the procedure was conceived with the idea of releasing arteries that have been spasmodically closed—the Raynaud type—and that may or may not be correct, depending on one's anatomical viewpoint. But, in practically all the cases I see, the arteries are closed not by spastic contractions of the blood vessel wall but by an obliterative process of one kind or another, most usually thrombus formation. And nothing can clear them. So that all I hope to do by a sympathectomy is to relieve pain—by breaking the sympathetic nerve chain—to dilate any vessels that can be dilated thus, and to secure a bit better blood flow in this way to the parts that need it. If that can be accomplished—if the patient can be tided over his acute stress—it gives one a chance to develop his collateral blood channels, provided he has a blood pressure sufficiently high to do it, or provided his low pressure can be raised a bit, as is occasionally possible.

A follow-up of the 9 cases reported in 1925 reveals the fact that one of the successes turned out later to be a failure in that the patient returned with ulcerations that could not be healed and pain that could not be controlled. Amputation followed. To counterbalance this, though, 2 cases, the one that was considered as being only improved and the one that was regarded as doubtful, have turned out quite successfully in that both patients have had little or no trouble and are able to attend to their usual duties. Analysis of these 9 cases, then, shows 4 failures and 5 (55.5 per cent) successes. There was 1 death among the failures. This occurred 2 days after the

[1]Bernheim, Bertram M. Blood pressure findings in circulatory disorders of the extremities. J. Am. M. Ass., 1922, lxxviii, 799–800. Significance of blood pressure in circulatory disorders of the extremities. South. M. J., 1927, xx, No. 4.

TABLE I.—ANALYSIS OF ENTIRE SERIES

Operations	Cases
Endarteritis obliterans	2
Thrombo-angiitis obliterans	15
Raynaud's disease	5
Arteriosclerosis	3
Erythromelalgia (arteriosclerosis)	3
Total operations on 25 patients	28
Deaths	
Hemiplegia, 2 days after second sympathectomy	1
Surgical infection	1
Cardiorenal, after amputation	1
Total deaths	3
Failures	17
Successes (39 per cent)	11

patient's second sympathectomy and was occasioned by a hemiplegia—an occurrence, by the way, that is not so infrequent in thrombo-angiitis obliterans. I had one patient who died of it on the eve of his scheduled operation.

Study of the 19 additional cases shows that 13 operations resulted in failure and 2 of these patients died. One died as a result of an accidental surgical infection, while the other died following the amputation that was done when sympathectomy failed to help matters. There were 6 successes or 31.5 per cent—a very respectable percentage,[1] when one considers that in certain cases the operation was purely experimental and failure was almost a foregone conclusion, while in practically all of them it was late in the course of their disease processes, much valuable time had been lost, and sympathectomy was done as a last resort.

[1]The explanation of the greater percentage of successes among the first group of cases is had in the fact that certain cases were done in the second group by way of experiment—always, of course, with the complete understanding on the part of the patient that it was a trial only. Two of these cases were for erythromelalgia, 1 was for a most unusual case of scleroderma that was thought to be linked up with Raynaud's disease, and another was for a most obscure nervous disorder that might possibly have concerned the sympathetic innervation of the arteries. In no case was there a threatened gangrene nor did gangrene supervene after operation. Pain was the chief symptom. The operation did not relieve the pain in any case, so I count all of them as failures. This explains in great measure, though, the difference in percentage successes between the first and second series.

ANALYSIS

A complete analysis of the entire series is shown in Table I.

In view of the fact that the operation is not especially dangerous, that it can be done under local anæsthesia as well as under general anæsthesia, that hospitalization of hardly more than 1 week is required, that there is little or no discomfort following it, that it is usually well borne even by patients over 60 years of age, and that in certain cases the result is actually brilliant, it would seem fair to conclude that in selected cases of circulatory disorders of the extremities peri-arterial sympathectomy really has much to offer.

THE SEDIMENTATION TEST IN PREGNANCY AND IN THE PUERPERIUM

A Study of Five Hundred Forty Patients

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THE blood sedimentation test, as a non-specific reaction in various infections and destructive diseases, has been studied by many investigators during the past 10 years. Its clinical significance in acute and chronic infectious disease, and in malignant conditions, has been discussed at considerable length in numerous papers. Its significance in pregnancy has, however, not been studied so intensively, although the fact that the sedimentation rate is increased in the pregnant state was pointed out by Fåhraeus, in 1918.

The purpose of the present study is to evaluate the sedimentation of the erythrocytes in pregnancy, with special reference to its relation to anæmia. The existence of a blood deficiency in pregnancy was described by us in a previous paper.

A true estimate of the value of the blood sedimentation test is rendered difficult by the lack of standardization in the methods employed in the test. A modification of either of the two best known methods is usually employed in the determination of the sedimentation rate. In one method (Westergren) the distance which the erythrocytes have settled in a given period of time is observed. In the Linzenmeier method, the time required for the sedimenting cells to reach a certain distance in the tube is recorded.

In this study the Cutler graph method (7) was employed because of its simple technique nd because of the ease with which the results could be graphically recorded.

The technique of this method, briefly, is as follows: a glass tube with a capacity of 5 cubic centimeters is employed. This tube is graduated in millimeters, each millimeter representing 0.1 cubic centimeter. A syringe, which contains 0.5 cubic centimeter of a 3 per cent solution of sodium citrate, is used to draw 4.5 cubic centimeters of blood from a vein. The syringe is then emptied into the tube. The position of the sedimenting column is noted every 5 minutes for 30 minutes, and again 15 and 30 minutes later. The observations are recorded on the sedimentation charts (Fig. 1) on which the abscissæ represent the divisions on the sedimentation tube and the ordinates represent the time intervals.

We adhered to the rule followed by Cutler in determining the sedimentation time. The time at which the erythrocytes settle a distance of less than 1 millimeter in 5 minutes is recorded on a chart. This point is the sedimentation time. Thus, the sedimentation time for the diagonal curve shown in Figure 1 is 45 minutes and for the vertical curve 30 minutes. If the sedimentation time is over 30 minutes but less than 60 minutes, the graph is a diagonal curve; if the time is 30 minutes or less, the curve is vertical. Sedimentation is not complete at the end of 1 hour in cases giving horizontal or diagonal lines and, therefore, the sedimentation time is not recorded in these cases.

REVIEW OF LITERATURE ON SEDIMENTATION TEST IN PREGNANCY

In 1918, Fåhraeus (11) was accidentally attracted to the accelerated sedimentation of the erythrocytes in the citrated blood of pregnant women. He found the sedimentation rate often 50 to 100 times more rapid in the pregnant than in the non-pregnant.

Friedlander also observed an increased sedimentation in pregnancy (Linzenmeier method). Although he admitted that the test yields no practical results for the diagnosis of pregnancy, he believes that negative findings are of material aid in differentiating pregnancy after the fourth month from simple tumors.

Neumann and Dogliotti noted a practically normal sedimentation rate in the first 3

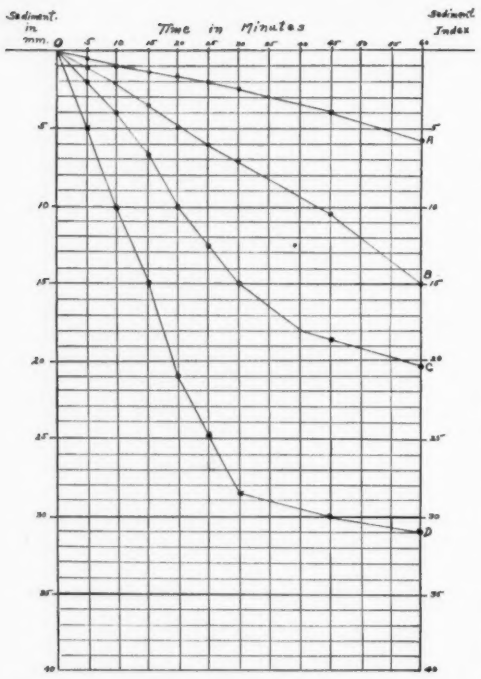

Fig. 1. Graph of the four types of curves obtained by recording the sedimentation in millimeters every 5 minutes up to 30 minutes, and again 15 and 30 minutes later. *A*, The "horizontal line"—a straight line—sedimentation index falling within normal limits (below 10). *B*, The "diagonal line"—a straight line—sedimentation index beyond normal limits. *C*, The "diagonal curve"—a curve of gradual descent—sedimentation time of 30 to 60 minutes. *D*, The "vertical curve"—a curve with a sharp descent—sedimentation index beyond normal limits, and sedimentation time of 30 minutes or less.

months of gestation and a steadily increasing rate in the second half of pregnancy.

In a study of 190 patients in all periods of pregnancy, Falta observed an increased rate after the first 3 months. The most rapid sedimentation occurred during the third stage of labor, and the velocity of sedimentation increased during labor even in cases in which high values were already obtained during pregnancy.

Pratucevitsch studied the sedimentation test in 41 gravid women. In 20 of these, pregnant 6 to 8 weeks, the sedimentation rate varied from 4 to 20 millimeters in 1 hour (normal, 6 to 8 millimeters). The rate was more rapid in the fourth and fifth months of pregnancy, varying from 15 to 32 millimeters in 1 hour.

Alexander, in a study of 42 gravid women, found an increased sedimentation rate in all patients after the third month of gestation. He believed that, with a normal sedimentation time, pregnancy of more than 3 months is very unlikely. Zeckwer and Goodell, and Noyes and Corvese have made similar observations.

RESULTS OF SEDIMENTATION TEST IN PREGNANCY

The sedimentation tests performed upon 540 women in different months of gestation were analyzed. These women were free from infectious disease and complications of pregnancy at the time of examination.

Table I portrays the general results of the test, whereas Table II subdivides the results according to the months of pregnancy. It is observed from Table I that 536 patients (99 per cent) had an increased sedimentation index in pregnancy. The more rapid sedimentation, as represented by a diagonal curve, was noted in 250 patients (46 per cent), while 112 patients (20 per cent) gave the most rapid acceleration, represented graphically by a vertical curve (sedimentation index less than 30).

Table II shows that of the 6 women examined as early as the second month of gestation only 3 showed an increased sedimentation index, the 3 others being normal. It is to be especially noted that none of the patients had a normal rate after the third month. Of the 453 women examined in the sixth month of gestation or later, practically 75 per cent showed the marked acceleration represented by a diagonal or vertical curve.

RELATION OF SEDIMENTATION TO ANÆMIA

It has been pointed out by many authors that the concentration of the erythrocytes alters the sedimentation rate. Rubin and Smith (30), Morris and Rubin (23), Groedel and Hubert, Hubbard and Geiger, and others have shown that the sedimentation is slow in polycythæmia and rapid in anæmia.

Rubin and Smith found that the lower the hæmoglobin content of the blood, the more

TABLE I.—RESULTS OF SEDIMENTATION TEST IN 540 PREGNANT WOMEN

Graph	No. of cases	Per cent	Sedimentation index (millimeters) <10	<15	<20	<25	<30	<35	<40
Horizontal line.	4	.7	4	0	0	0	0	0	0
Diagonal line..	174	32.2	0	14	61	84	16	2	0
Diagonal curve.	250	46.4	0	0	5	69	155	21	0
Vertical curve..	112	20.7	0	0	0	7	53	47	5
Total.....	540								

<Less than.

frequently is increased sedimentation obtained. They hold that this relationship also applies to the red cell count, so that with a decrease in the erythrocyte count there is a proportionate increase in sedimentation, and vice versa. Since, clinically, a marked anæmia produces an increased rate of sedimentation, they believe that the volume of red cells (as determined by hæmocrit) exerts an important influence on the reaction under all conditions.

Hubbard and Geiger found that rather slight variations of the normal red cell count apparently produce marked differences in the sedimentation rate.

Schumacher and Vogel, and Clauser hold that in anæmia there are accompanying changes in the blood which will modify the sedimentation, and that these variations are not to be taken as evidence of inflammation.

Ordinarily, proper allowance has not been made for the fact that a definite anæmia coexists in many inflammatory and other conditions usually associated with a rapid sedimentation. If this test is to be accurately evaluated in various clinical conditions, the effect of blood deficiency *per se* in producing accelerated sedimentation must be distinguished from an increase produced by the existing disease. Although it has been found that the sedimentation rate is increased in pregnancy, the fact that a moderate to a severe grade of anæmia is "normally" associated with pregnancy has been more or less disregarded in sedimentation studies in the gravid state.

We have, therefore, attempted a parallel study of sedimentation and erythrocyte count, during pregnancy and after delivery, in the same group of patients.

Table III analyzes the sedimentation rates according to the erythrocyte counts. In accord with our previous study, it is observed that 268 (49.6 per cent) of the women gave counts under 3,500,000. Only 2 of the 461

TABLE II.—SEDIMENTATION RATES ACCORDING TO MONTH OF PREGNANCY

Graph	Month of gestation 2nd	3rd	4th	5th	6th or later	Total
Horizontal line.	3	1	0	0	0	4
Diagonal line..	3	23	18	16	114	174
Diagonal curve.	0	2	9	9	230	250
Vertical curve..	0	1	2	0	109	112
Total.....	6	27	29	25	453	540

TABLE III.—SEDIMENTATION RATE IN RELATION TO ERYTHROCYTE COUNT

Red blood cells millions per c.cm.	No. of cases	Graph Horizontal line	Diagonal line	Diagonal curve	Vertical curve	Diagonal and vertical curves No.	Diagonal and vertical curves Percentage
4 or more.....	79	2	53	19	5	24	30
3.5–3.99.....	193	2	71	94	26	120	62
3–3.49.....	182	0	43	93	46	139	70
Less than 3....	86	0	7	44	35	79	91
Total.....	540						

patients with counts below 4,000,000 showed normal sedimentation, whereas 459 had a sedimentation rate represented graphically by a diagonal line, diagonal curve, or vertical curve. However, of the 79 patients with no anæmia (over 4,000,000 cells), 77 gave an increased sedimentation rate, although in 53 of these it was only slightly above normal (diagonal line).

On superficial examination of these results it seems that the erythrocyte count does not materially influence the sedimentation rate. If the patients with a rate equivalent to a diagonal or vertical curve are grouped according to their respective counts, quite different results are obtained (Table III). It is observed that only 24 (30 per cent) of the 79 patients with a normal red cell count had either a diagonal or a vertical curve, whereas the percentage of patients with a rapid sedimentation (equivalent to a diagonal or vertical curve) became considerably higher as the anæmia became more marked. Of the 86 patients with a count below 3,000,000, 79 (91 per cent) had a sedimentation velocity equivalent to either a diagonal or vertical curve. Anæmia, therefore, probably is a factor in determining the rate of settling of the erythrocytes in pregnancy as in other pathological conditions.

RELATION OF LEUCOCYTE COUNT TO SEDIMENTATION RATE

To determine the relationship between the leucocyte count and the sedimentation rate in

TABLE IV.—SEDIMENTATION RATE IN RELATION TO LEUCOCYTE COUNT

White blood cell count per c.cm.	No. of cases	Graph: Horizontal line	Graph: Diagonal line	Graph: Diagonal curve	Graph: Vertical curve	Total and per cent of diagonal and vertical curves
15,000 or more	26	0	2	19	5	24(92)
10,000–14,900	120	0	35	63	22	85(71)
Less than 10,000	394	4	137	168	85	253(64)
Total	540					

pregnancy, the various curves obtained have been arranged in Table IV according to the leucocyte counts at the time of examination. This table shows that 24 (92 per cent) of the 26 patients with leucocytosis (15,000 leucocytes per cubic millimeter) gave a very rapid sedimentation rate (equivalent to a diagonal or vertical curve), whereas the percentage of patients exhibiting this rapid sedimentation decreased as the number of leucocytes diminished. It may, therefore, be assumed that an increased number of leucocytes can, also, influence the sinking time of the erythrocytes.

THE BLOOD SEDIMENTATION VELOCITY IN THE PUERPERIUM AND LATER

Friedlander noted that a rapid sedimentation occurred in the puerperium, as well as during pregnancy. The sedimentation rate, however, diminished after the tenth day of the puerperium, returning to normal in about 4 weeks, provided the lying-in period is not complicated with infection.

According to Linzenmeier and Falta, an inhibition in the velocity of sedimentation occurs 10 days after labor. This, however, is subject to fluctuation, due probably to the variation in the healing processes of the endometrium. These authors state that the sedimentation reaction returns to the normal of the non-pregnant woman after the third week.

Falta emphasizes that puerperal infections, lochiometra, hæmorrhage, and perineal lacerations cause a delay in return of the sedimentation rate to the value of the nonpregnant state.

The studies of Neumann disclosed that the sedimentation velocity starts to increase immediately after separation of the placenta and continues during the puerperium, reaching its maximum on the seventh day. He noticed a further increase in the rate during the puerperium even in those patients who had shown

TABLE V.—FIBRINOGEN CONTENT IN PREGNANCY, ACCORDING TO GRAM

Month of pregnancy	No. of cases	Average percentage of fibrinogen
Second	1	0.33
Third	1	0.42
Fourth	3	0.36
Fifth	4	0.39
Sixth	9	0.43
Seventh	10	0.46
Eighth	7	0.57
Ninth	7	0.49
Tenth	18	0.55

Note that the fibrinogen percentage after the fifth month of pregnancy is considerably higher than prior to the fifth month.

a very rapid sedimentation during pregnancy. He attributes this to resorption processes occurring in the uterus. This author investigated the further course of the sedimentation reaction in 75 patients during a period of 3 to 11 weeks after delivery. He found that in 54 cases (72 per cent) the rate returned to normal within 5 to 7 weeks after delivery, and he believes that a pronounced parallelism exists between the sedimentation reaction and the clinical processes of involution.

The sinking time of the red blood cells, in the 540 patients examined during pregnancy, was again determined in the puerperium. This examination revealed that the increased velocity persisted for 10 days after delivery.

In order to ascertain how soon after labor the sedimentation rate returned to normal, 100 patients having a sedimentation index of between 30 and 45 during pregnancy were reexamined at various intervals within 6 months. Eight patients, examined 4 weeks after delivery, gave a sedimentation rate equivalent to a diagonal line; whereas the 92 remaining, after the first month, exhibited slow sedimentation with an index of 6 to 10 millimeters.

Of the 100 patients studied, 78 had an erythrocyte count below 3,500,000. On reexamination within 6 months after delivery, all had gained between 200,000 and 500,000 red cells, 72 having reached the 4,000,000 mark. From these results, it seems that the increased number of corpuscles had been an important factor in causing the delayed sedimentation during the postpuerperal period.

DISCUSSION

Various explanations have been advanced as to the cause of the sedimenting property of the red blood cells.

Cordua and Hartman observed that a hyperinosis, or an increased fibrin (fibrinogen) content of the plasma, existed in all conditions with acceleration of sedimentation. Bruchsaler found that the blood plasma, during the last weeks of gestation and immediately after delivery, showed a marked increase in the content of fibrinogen, as compared with that in women with normal sedimentation. From this observation, he concluded that fibrinogen is the chief bearer of the properties which hasten sedimentation.

Fåhraeus (10, 11) and Linzenmeier favor an electrophysical explanation for the increased sedimentation in infections.

Mikulicz-Radecki, Risse, and Meeker believe that the phenomenon of sedimentation is due to the instability in the ratio of the albumin and globulin fractions of the serum. They found a decrease in the albumin fractions and an increase in the globulin and fibrinogen elements in cases with rapid sedimentation.

Gram analyzed the fibrin content of 542 plasmas and observed an increase of fibrin in all infectious diseases, cancer, nephritis, and pregnancy. The mean value of the fibrin percentage per 100 cubic centimeters of plasma in normal women was 0.29 per cent. In simple anæmia, he found the fibrin percentage in the plasma to be normal. In pregnancy, he nearly always found a moderate to a severe grade of anæmia and an increased percentage of fibrinogen. The average fibrinogen content in pregnancy, as determined by Gram, is listed in Table V.

On the basis of these observations, he concluded that the sedimentation depends on two factors: (1) cell volume percentage and (2) fibrin (fibrinogen) percentage in the plasma. The tendency to hyperinosis begins early in pregnancy but does not always reach beyond the upper boundary of the normal before the fifth or sixth month. Gram considered the increased fibrinogen as being an expression of the introduction of foreign proteins in the blood and believed that the fibrinogen brings about the accelerated sedimentation by causing an agglutination of the erythrocytes which facilitates their sedimentation.

These observations are important in view of the fact that we found a marked increase in the sedimentation rate of the blood in 362 pregnant women. The rapid sedimentation, we believe, depends on the fibrinogen content of the plasma, although the existence of anæmia and leucocytosis may play a rôle in altering the degree of rapidity.

The question now arises as to the significance of the physiological acceleration of sedimentation in pregnancy. It is generally recognized that fibrinogen, existing in solution in the blood, is the essential factor in the coagulation of the blood. A slow sedimentation in pregnancy indicates that the fibrinogen content, for some reason, has not changed from that of the non-pregnant state, or else is diminished. The sedimentation value may, therefore, be considered as an index of the coagulating property of the blood. A prolonged or a delayed sedimentation forebodes a delay in coagulation at the time of expulsion of the fetus and placenta, with the likelihood of postpartum hæmorrhage. Furthermore, a patient with a severe grade of anæmia and a slow sedimentation in pregnancy would be extremely likely to develop excessive bleeding during or after labor.

The fact that a rapid sedimentation is almost always associated with normal pregnancy after the third month may aid in differentiating a myomatous uterus from a pregnant one, since an uncomplicated myoma does not alter the sedimentation rate of the blood.

SUMMARY

1. The blood sedimentation test was performed upon 540 gravid women in the different periods of pregnancy and in the puerperium. In 536 patients, sedimentation occurred more rapidly than in the normal non-pregnant patient.

2. Of the 453 women examined in the sixth month of pregnancy or later, 75 per cent showed a marked acceleration of sedimentation, equal to either a diagonal or vertical curve.

3. Of 79 patients with an erythrocyte count of 4,000,000 or more, 24 (30 per cent) gave either a diagonal or vertical curve; whereas, of the 86 patients with a severe anæmia (counts below 3,000,000), 79 (91 per cent) had a sedimentation velocity equivalent to either a diagonal or vertical curve.

4. Of the 26 patients having a high leucocyte count (15,000 or over), 24 (92 per cent) showed a very rapid acceleration, whereas 64 per cent of the 394 patients having a leucocyte count below 10,000 gave a sedimentation rate equivalent to a diagonal or vertical curve.

5. The same sedimentation rates as occurred during pregnancy were maintained during the first 10 days after delivery.

6. The sedimentation reaction and the erythrocyte counts returned to the normal of the non-pregnant woman in practically all the women examined within 6 months after delivery. Of the 100 women examined within 6 months after labor, 92 exhibited a slow sedimentation, with an index of 6 to 8 millimeters.

CONCLUSIONS

1. Sedimentation of the erythrocytes in pregnancy is considerably more rapid than in the non-pregnant state.

2. This acceleration is probably primarily dependent upon the increased fibrinogen content of the plasma and, secondarily, on the anæmia and leucocytosis physiologically present in pregnancy.

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THE EFFECT OF SERUM FROM PREGNANT WOMEN ON THE ŒSTRUAL CYCLE OF THE GUINEA PIG

A Preliminary Report Upon the Possibility of Its Use as a Test for Pregnancy[1]

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IT has been definitely shown that the corpus luteum hormone has an inhibitory influence on the œstrous activities in certain lower forms, notably the guinea pig (3) and the rat (5). More recent investigations have confirmed this work.

Papanicolaou (3) writes of the antagonistic properties of the female sex hormone (œstrin) and the corpus luteum hormone, and Parkes has advanced the idea that these two endocrine products of the ovary are antithetically opposed to each other and that during pregnancy the corpus luteum hormone is in the ascendancy until the time of parturition. It is a well known fact that guinea pigs, rats, and mice come into œstrus immediately after parturition and will copulate at that time.

By injecting female sex hormone (œstrin) into white mice, Parkes and Bellerby found they could prevent conception or terminate pregnancy at any stage. The addition of the œstrus-producing hormone upset the balance between the two hormones and threw the genital tract into a state incompatible with the normal continuance of pregnancy. In view of the recent contributions of Corner and Allen on the functions of the corpus luteum hormone it is easy to comprehend how an ascendancy of œstrin could prevent conception. These authors have given experimental proof that the corpus luteum hormone exerts an essential influence on the mucosa of the uterus in its preparation for the nidation of the fertilized ovum.

Margaret Smith tested the effects of similar injections in white rats and found she could interrupt pregnancy up to the fifth day but not thereafter, although she injected as high as 80 rat units into a single animal. We have been carrying on a like study of the guinea pig, in which we have been able to prevent conception and, with very large doses, to interrupt the normal course of pregnancy at any stage. This work has not yet been completed.

On the premise that during pregnancy there is an excess of corpus luteum hormone over the œstrus-producing hormone and on the basis of the knowledge that the corpus luteum hormone inhibits œstrus, we undertook to ascertain if injections of serum from women known to be pregnant would inhibit œstrus in the guinea pig. This animal has a very definite and clear-cut œstrus cycle (8) and by means of vaginal smears the exact stage of heat can easily be ascertained.

A group of animals was selected and their cycles determined over a period of several weeks. Only animals that were healthy and regular were used. They were divided into three groups, the first to be used as test animals and the second and third as controls. The second group received injections of serum from non-pregnant women and the third group injections of a 1 per cent peptone solution.

The blood was collected in test tubes and the clots broken with a sterile glass rod. After about 24 hours the serum was transferred to sterile 1 ounce vaccine bottles with rubber stoppers and placed in the ice box. It was drawn from the bottles in the usual aseptic manner when injections were made.

In all cases the injections were begun on the ninth day of the cycle, which averages between 15 and 16 days. This was in accordance with the observations of Papanicolaou (3) that injections begun at this time were more effective than when started later in the cycle. The injections were given daily for 4 days and the total quantity varied from 10 cubic centimeters to 20 cubic centimeters. We began with 2 cubic centimeters as a rule and increased the dose each day. Many of the injections were made intraperitoneally, while others were made subcutaneously in the flanks.

The results in the first group showed a delay in the onset of œstrus, the postponement

[1]Contribution No. 5, Series B, from the Department of Anatomy of the Medical Department of the University of Georgia. This investigation has been aided by a grant from the National Research Council through its Committee for Research in Sex Problems.

TABLE I.—ANIMALS RECEIVING SERUM FROM PREGNANT WOMEN

Animal number	Cycle, days	Injections	Total c.cm.	Delays, days
1140	14	4	10	8
1142	16	4	20	5
1145	14.5	4	14.5	7
1149	16	4	12	3
1181	14	4	14	5
1180	14	4	14	7
1179	16	4	14	5
1188	14	4	14	7
1193	14	4	13	7

Total animals, 9. Average delay, 6 days.

TABLE II.—ANIMALS RECEIVING SERUM FROM NON-PREGNANT WOMEN

Animal number	Cycle, days	Injections	Total c.cm.	Delay, days
1131	13	4	20	0
1032	15	4	20	2
1183	16	4	14	0
1186	14	4	14	1
1190	14	4	14	1

Total animals, 5. Average delay, 0.8 day.

varying from 3 to 8 days, with an average of 6 days (Table I).

According to Papanicolaou (3) a corpus luteum unit is defined as that quantity necessary to postpone ovulation in the normal guinea pig for 1 day. On this basis the average quantity of serum used with this group of animals contained 6 units of free corpus luteum hormone. By free, we mean in excess of the amount required to neutralize the female sex hormone, assuming that these hormones can offset each other in such a manner.

In the second group of 5 animals, serum from non-pregnant women was injected, each one receiving a total of from 12 cubic centimeters to 20 cubic centimeters over a period of 4 days in increasing dosage. In this group the onset of œstrus was postponed from 0 to 2 days, the average being 0.8 day. Since the cycle of a given animal may vary 1 day from one period to the next, this delay lacks significance. (Table II.)

In the third group of 4 animals each one received a total of 20 cubic centimeters of 1 per cent peptone solution in 4 days. In none of the members of this group was there any delay in the onset of œstrus. (Table III.)

It is worthy of note that the average length of the œstrual cycle in days is shorter in our animals than the averages of Stockard and Papanicolaou (15.73) and Selle (15.87). Whether this is due to the warmer climate, we cannot say, but the cycles of our animals were determined very carefully over a number of periods by the vaginal smear method and we believe them correct. It is interesting also to note that, whereas the age at which female guinea pigs reach sexual maturity is given as about 3 months, the majority of ours have their first œstrus somewhat earlier, some when less than 2 months old.

TABLE III.—ANIMALS RECEIVING 1 PER CENT PEPTONE SOLUTION

Animal number	Cycle, days	Injections	Total c.cm.	Delay, days
1007	15	4	20	0
1033	15	4	20	0
1004	15	4	20	0
1156	15	4	20	0

Total animals, 4. Average delay, 0 days.

Another point that should be noted is that we calculated our cycles from onset to onset (that is, from first stage to first stage), whereas Papanicolaou in defining a corpus luteum unit, calculated from ovulation to ovulation, which occurs at the junction of stages 2 and 3 of œstrus as shown by the vaginal smear method. This difference in method of calculation would not give any discrepancy in days, however, since the same starting and ending points were used in each case.

In this work we have not as yet made any effort to ascertain whether the effects vary if the serum is obtained from women in early, middle, or late pregnancy. Our main purpose was to determine if serum from women known to be pregnant would cause a postponement of œstrus in the guinea pig. Our next step will be to have serums from unknown sources submitted in a large series of cases so that we can check the efficiency of the method in diagnosing pregnancy.

If this method should prove dependable for this purpose, it would require for its use a colony of female guinea pigs with an attendant to take smears daily from all animals with open vaginas, so that each individual cycle would be definitely known. The orifice of the guinea pig vagina cicatrizes between heat periods (and during pregnancy)[1] and opens again at œstrus (for about 4 days). This is a time-saving factor, since it can be taken for

[1] Kelly and Papanicolaou.

granted that no animal with a closed vagina is in heat and no smear need be taken under such circumstances.

The time required for a report in any case would vary from a week to 10 or 12 days, depending upon whether the result is negative or positive. If negative, the vagina would open in a week or less from the beginning of injection (ninth day of cycle). If positive, the result could be presumed on the tenth day after beginning injections and should be certain by the twelfth.

Some of our animals succumbed to the injections of serum. It would therefore be in order to determine if injection of smaller as well as the larger quantities of serum from pregnant women will postpone œstrus. In practice, it might be advisable to use two animals for each test, in case one should die. The quantity of blood required for the test would average about 50 cubic centimeters.

We found that animals which had received serum once could not be used again, as they promptly died from anaphylaxis when the second series of injections was begun.

Of course, it cannot be taken for granted that the corpus luteum hormone in the serum from pregnant women is the only factor causing the postponement of œstrus; there may be others. Hormones from the fetus or the placenta must be considered. However, this investigation shows there is a qualitative difference between the serums of pregnant and non-pregnant women and that this difference can be detected by a method of biological assay that may be turned to a practical advantage, namely, the diagnosis of pregnancy in the human. This paper is written in the nature of a preliminary report and the refinement of the method lies in the future.

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THE FUNDAMENTAL OPERATIVE TREATMENT OF INGUINAL HERNIA

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THE initial paper of this series (8) dealt with the demonstration of a true inguinal sphincter, formed around the abdominal os of the inguinal canal by circular fibers of the internal oblique and transversalis muscles. The data submitted in the former article also indicated that this sphincter is voluntary in character and normally functions to protect the internal opening of the inguinal canal, first, by a constant state of tonus, and second, by voluntary reflex contractions whenever the intraperitoneal pressure is, for any reason, increased. Further, evidence was presented toward the proof that the usual method of production of an indirect hernia is by the extrusion of a peritoneal wedge into the inguinal canal through an increasingly insufficient internal inguinal sphincter, the prime moving factor being the piston-valve-like action of the vacillating intraperitoneal pressure. To sum up, anatomical, empirical, and experimental evidence was adduced to prove that the primary etiological factor in the causation of inguinal hernia is an insufficiency or paresis of the internal inguinal sphincter, and that any procedure directed at the operative cure of the hernia must have as its basis the correction of this fundamental sphincteric failure. In the present article, the details of such an operative procedure will be given. It may be well, however, with the above conception in mind, first to review the imperfections inherent in the current hernia operations, in order to clarify and emphasize such departures in technique as will later be advocated. Accordingly, the following brief account of the procedures in current use for the operative cure of inguinal hernia may be found explanatory and convenient.

CURRENT OPERATIONS

Among the most important and typical of these are the Bassini, Ferguson, and Halsted, any of which may be modified or combined with the Andrews' method of closure.

Bassini originally emphasized the high ligation of the sac, transplantation of the cord, and adequate repair of the posterior wall of the inguinal canal. In the modified Bassini, as now frequently employed (10), an incision through skin and fascia is made parallel to, and one-half inch above, Poupart's ligament. The aponeurosis of the external oblique is next divided longitudinally, so that an adequate inferior flap is left. The hernial sac is than separated, emptied, incised, ligated proximally, severed, and removed. With the cord retracted laterally, the internal oblique and transversalis above, and the conjointed tendon below, are sutured to the shelving edge of Poupart's, the region of the internal ring being made "snug" by a Coley suture above the entrance of the cord. This structure is then transplanted and covered by imbricating the two flaps of external oblique aponeurosis. The skin wound is closed by a subcuticular stitch.

Ferguson attempts a more extensive repair of any deficiency of the internal ring. He employs a higher incision and separates the two flaps of the external oblique aponeurosis up to the level of the anterior superior spine. He then sutures the separated fibers of the internal oblique and transversalis back to their defective origin from the upper portion of Poupart's ligament, and, if necessity arises, may actually transplant a higher portion of these muscles to the region around the entrance of the cord. In case of complicating direct hernia, he advocates transplantation even of the rectus, and its suture to the lower portion of Poupart's. The cord is not disturbed in the above technique.

Halsted (Johns Hopkins) employs a flap of cremaster to strengthen the posterior wall of the canal, and to bridge any gap, posteriorly, between the internal muscles and the inguinal ligament. Mattress sutures are employed for the union of the cremaster fascia and muscle with the posterior aspect of

the transversalis and internal oblique. In his operation also, as in the Ferguson, the cord is not disturbed, nor is especial attention paid to the internal ring. Closure is effected by the overlapping of the aponeurotic flaps.

Other modifications of technique have at various times been advocated. Thus, Halsted originally advanced an operation, which has been lately revived and in which the cord was transplanted external to the aponeurosis. Again, Watson recommends lateral displacement of the cord out of the line of deep suture and enforces this by stitching the external oblique aponeurosis to the internal muscle immediately lateral to the new position of the cord. Scott places the cord under the upper half of the aponeurotic sutures and over the lower half, thus permitting an adequate closure of the external ring. Finally, in the Andrews' method of closure, sufficient lower aponeurotic flap is left so that a secure "double breasted" imbrication of the two flaps may be effected, the upper internal flap being sutured either anterior or posterior to the cord.

Every one of the above operations presents points of surgical excellence. As has been indicated, however, there are certain theoretical and practical defects inherent in many of the procedures. To summarize briefly:

1. Muscle tissue, when so transplanted as to act obliquely to the direction of its fibers, is not only ineffective, but is soon rendered practically functionless through fibrous degeneration.

2. Adequate anatomical union, as proved by Cavell, cannot occur unless fascia-to-fascia and muscle-to-muscle suture is employed. Ultimately, any other method of approximation will be found to result in unsatisfactory fusion.

3. Any attempts at the repair of the internal ring either by oblique muscle transplants, or by pinching the fascia and muscles about the internal os with sutures, must remain inadequate, since for both of the reasons mentioned, adequate functional restoration of the muscles cannot ensue. Transplantation of the internal oblique, incidentally, must necessarily obviate the valve-like closing action which this muscle exerts on the inguinal sphincter.

4. Fascial transplants, as frequently employed, can evidently not have any supportive muscular action, and when once loosened must remain permanently so.

Most important of all, however, is the consideration that, since the basic etiological factor in the causation of inguinal hernia is an insufficiency of the internal inguinal sphincter, rational operative procedures must have as their prime object the correction, in so far as possible, of that insufficiency, and need only secondarily be concerned with the subsequent closure of the inguinal canal. Accordingly, the irrationality of such procedures as the suturing of the internal os to the peritoneum, or the deliberate division of the former, as employed by Davies, is obvious.

RESULTS OF THE PRESENT OPERATIONS

The validity of the above objections may be appreciated by considering the results that have been and are being obtained by the use of the current operations. A review of the literature reveals the fact that the percentages of hernial recurrence, as reported by capable operators, range from 6.5 to as high as 17.5 per hundred cases. Thus, of 978 cases of inguinal hernia traced by Erdmann, hernia recurred in 74. In the French navy, the recurrence of inguinal hernia following operation, as reported by Oudard and Jean, reached 10 per cent. When the inguinal protrusion is associated with direct hernia, the percentage of recurrence, as estimated by Watson, is from 10 to 20, even in the hands of the most experienced operators. Even these comparatively high figures are misleading, in that, in many of them, the recurrences represent only those patients who voluntarily return to the same clinic for reoperation, or who have reported a recurrent hernia large enough to be diagnosed by the patient himself. Obviously, therefore, if all cases were followed for a sufficient length of time (5 to 10 years) the percentage of recurrence would be found to be considerably higher than at present realized.

Significant also is the fact recorded by Watson: "Oblique inguinal hernias most

frequently recur through the opening left for the cord or a weak spot in muscle or fascia." This statement alone would indicate that the chief weakness of the older operations is their utter disregard of the prime functional importance of the muscular sphincter about the internal os, and their inefficiency in the repair of this sphincter.

THE TECHNIQUE

With the above considerations in mind, the author has devised, and has practiced, certain modifications of technique that have been productive of entirely satisfactory results. In effect, his procedure is as follows:

After the usual Bassini incision, a grooved director is inserted between the pillars of the external ring, and the aponeurosis of the external oblique split in the direction of the internal os. If the operator intends subsequently to employ an Andrews' closure, it is best that this splitting be done above the line of the cord, so that a sufficient inferior aponeurotic flap be left for imbrication. Retraction now reveals the full extent of the canal. The sac is separated, emptied, ligated, and excised in the orthodox manner—high ligation of the sac (since it removes the paralyzing peritoneal cone) being one of the most commendable features of the older operations. The following important steps in the technique are characteristic of the procedure and now require careful attention:

The internal inguinal sphincter is identified and its relative insufficiency determined. Any defect is then corrected by displacing the cord to the upper inner quadrant of the ring, and so shortening and suturing (No. 1 chromic catgut) the lower outer fibers of the sphincter as best to restore the snugness and tonicity of the muscular ring. It is essential to note that these sutures in no way involve the shelving edge of Poupart's, but serve only to bring together the deficient lower outer portion of the inguinal sphincter. It is also essential that, throughout all of the manipulations no injury be done to the ilio-inguinal or iliohypogastric nerves, since traumatization of their motor fibers (8) may defeat the purpose of the entire operation by producing degenerative paresis of the internal inguinal sphincter.

If this technique has been followed carefully, the manner of subsequent closure of the canal and of the incision may be left to the choice of the operator—the variations of procedure, in my opinion, being of comparatively minor importance. In most instances, the anterior or posterior Wyllys Andrews' closure, as employed by the present author, will be found entirely satisfactory.

CONCLUSIONS

It may be noted that all of the steps of the procedure here advocated are based upon sound anatomical and surgical principles, i.e., the operation is physiologically rational and proceeds in a definite manner to correct a definite etiological defect. In effect, the time of operation is shortened, handling of the parts is reduced to a minimum, excess catgut is avoided, and the procedure redisposes all of the involved structures into the best (i.e., their original) muscle and fascial planes. Finally, the relative simplicity of its technique renders the operation capable of wide applicability.

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THE VALUE OF INDWELLING URETERAL CATHETERS IN URINARY SURGERY[1]

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SINCE urinary stasis has been recognized as the leading etiological factor in the pathogenesis of all pathological conditions of the kidney and of the whole upper urinary system, the value of the ureteral catheter in relation to diagnosis and treatment is beyond question. Its use has been essential and indispensable, since it combines the procedures of cystoscopy, urography, and roentgenography in routine examinations in diseases of the genito-urinary tract.

The marvelous clinical experience of former days is concentrated in this triple procedure of modern urology, namely, catheterization of the ureters, direct observation of the bladder, and urography. Without accomplishing these three elemental procedures in a given case, we would remain in the dark.

Nitze, in 1894, devised the first practical cystoscope. Albarran, in 1897, introduced the ingenious modification that made the catheterization of the ureters possible, and later, in 1906, Volker and Lichtenberg devised the injection of an opaque medium into the kidney pelvis, for the purpose of pyelography. Each one of these procedures complements the other; they constitute the three foremost steps of the most brilliant era in the development of accurate diagnosis in modern urology.

However, it is my purpose to discuss only the value and the use of the ureteral catheter —particularly of the indwelling ureteral catheter, so-called ureteral catheter *in situ*, *sonde á demeure*—retentive or fixed in place in the kidney pelvis after catheterization of the ureter has been accomplished and after the removal of the cystoscope.

I will endeavor, in this presentation, to bring to view, in a practical way, when and how a ureteral catheter should be used, reporting my personal experience with a few interesting cases, in which I have had most striking and satisfactory results, calling attention, at the same time, to the convenience and great importance of this simple procedure in three essential groups, namely, before, during, and after operation. I will attempt to illustrate briefly the striking results and the very great convenience of its use, not only to urologists who are well aware of its benefits, but for the purpose of popularizing this procedure among clinicians, surgeons, and general practitioners. (Table I.)

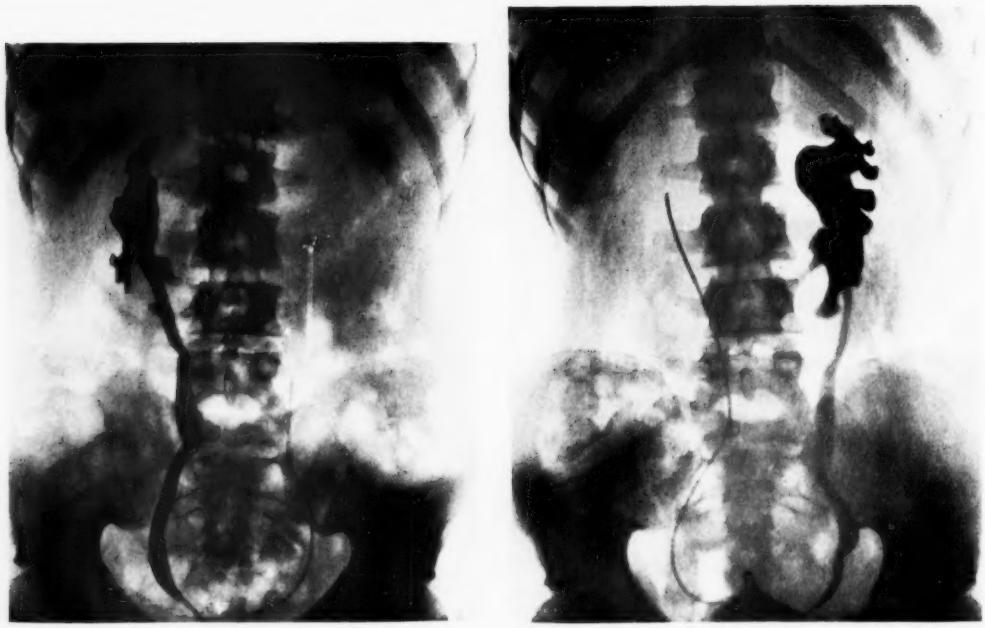
TABLE I.—THE USE AND VALUE OF INDWELLING URETERAL CATHETER BEFORE OPERATION

Diagnosis:
1. In all cases of kidney pathology.
2. In lesions of the ureter.
3. To exclude stone shadows and anomalies of the upper urinary tract.
4. For the purpose of pyelography and roentgenogram studies.
5. To estimate renal function.

Treatment:
1. To secure drainage of kidney pelvis in cases of infection and retention:
   1. Pyelitis,
   2. Pyelonephritis,
   3. Hydronephrosis,
   4. Pyohydronephrosis.
2. To dilate the ureter:
   1. Stricture,
   2. Kinks,
   3. Stone.
3. "Renal colic."
4. In so-called idiopathic hæmaturia.
5. In cases of anuria or uræmia.
6. In cases of infection of the kidney pelvis, including pyelitis of pregnancy and pyelonephroureteritis of infancy.
7. In cases of infected horseshoe kidney.
8. In polycystic kidney disease.
9. In ascending infection as in "urinary reflux."
10. For the purpose of kidney pelvis lavage when infection and fever are present, due to lack of drainage.
11. After pyelography, if the pelvis does not empty in 10 minutes, to relieve pain and secure drainage.

Before operation the fixed ureteral catheter is used first of all for the purpose of diagnosis and therapeutic treatment. It serves to collect specimens from each kidney pelvis for microscopical and bacteriological examinations and to determine renal function in regard to urea excretion and color dye elimination. Also, it

[1]Read before the Section of Genito-Urinary Surgery ,New York Academy of Medicine, May 15, 1929.



Figs. 1 and 2. Case 1. Right and left pyelogram of infected horseshoe kidney treated successfully with indwelling ureteral catheter.

serves, when combined with roentgenography, to detect the presence of urinary calculi or shadows within or without the urinary tract and to disclose certain anomalies and pathological conditions of the upper urinary system that are more clearly revealed in a pyelogram obtained after the injection of an opaque medium into the kidney pelvis.

This technical routine procedure in urological work is well known and perfectly standardized and is described in many publications so there is no need to emphasize it at this time. I wish to report only a few illustrative cases to show the value of the ureteral catheter for correct diagnosis and its striking results in therapeutic treatment. (Table II.)

During operation, the indwelling ureteral catheter has a definite place. Albarran, in describing its use in certain operations upon the ureter and kidney pelvis, calls attention to the facility and safety of the surgical procedure, both to the surgeon and to the patient. It affords identification readily with exposure of the catheterized ureter, eliminates errors and fears of cutting, clamping, or tying a normal ureter, and makes the surgeon more sure and confident, particularly in the very hazardous and difficult cases, or even in the rather common anomalous kidneys and ureters encountered at operation. This pre-operative cystoscopic procedure of catheterizing the ureter, which should not take more than two or three minutes to accomplish, is the best help and guide in kidney surgery; its merits deserve a wide general application in safe urological surgery. (Table III.)

During the postoperative care of surgical diseases of the kidneys, the use of the indwelling ureteral catheter should be a part of the treatment; mainly to prevent fistula or urinary stasis that may lead to infection or to delay the healing of the wound. It also secures perfect drainage by kidney pelvic lavage for the purpose of clearing up infection. Many authors have reported striking results in treating "renal colic" or calculous anuria with a fixed ureteral catheter combined with the use of forced fluids and intravenous in-

TABLE II.—THE USE AND VALUE OF INDWELLING URETERAL CATHETER DURING OPERATION

1. To verify a diagnosis.
2. As the best guide to identify the ureter and its anomalies.
3. To prevent migration of ureteral calculi.
4. To empty a big hydronephrotic sac which facilitates nephrectomy.
5. In pyelotomy and pyelonephrotomy.
6. In infected stump ureter.
7. In ureteral fistula.
8. In any operation upon the ureter:
    1. Ureterotomy,
    2. Ureterectomy,
    3. Ureteral anastomosis,
    4. Ureteroneocystostomy,
    5. Ureterostomy.
9. For the purpose of kidney pelvis irrigation and the maintenance of drainage.
10. In certain gynecological operations to avoid injury of the ureter.

TABLE III.—THE USE AND VALUE OF INDWELLING URETERAL CATHETER AFTER OPERATION

1. To obviate renal or ureteral fistula in certain cases of pyelotomy, nephrotomy, and ureterotomy for calculi.
2. With the purpose of kidney pelvis, lavage, and maintenance of drainage.
3. To secure healing of wound primarily, without leakage of urine.
4. For persistent renal bleeding.
5. In the occurrence of anuria or uræmia, combined with daily infusion.

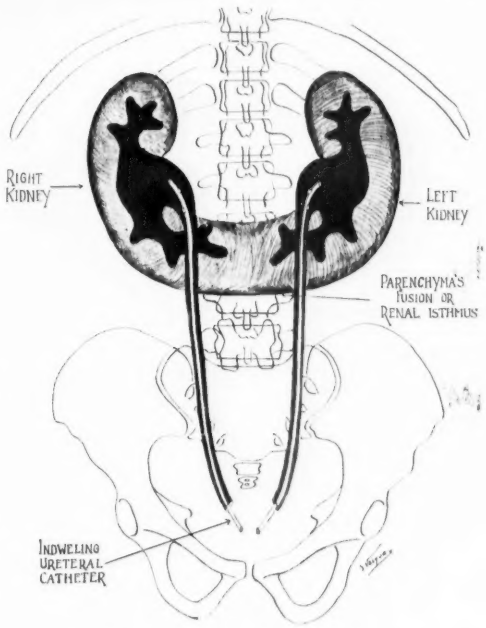


Fig. 3. Drawing of Case 1 showing the horseshoe kidney with its typical characteristics of kidney pelvis calyce pointing inward, also showing the indwelling ureteral catheter fixed in position for the purpose of kidney pelvis lavage and permanent drainage.

fusion of saline solution, and no doubt, many patients have been saved from fatal uræmia by this simple procedure.

Therefore, it is my purpose, after a review of the literature and our own personal experiences in routine work carried out in the Urological Department of the New York Hospital, to present a résumé of this subject. We see in our daily practice that all patients who come for examination, either surgical or medical, justify the classification of the three groups already described.

The catheter which should be used for the purpose of diagnosis is a No. 6 French X-ray catheter, because of the shadow cast by the roentgen-rays and the better contrast in the pyelo-ureterogram.

In routine treatment when the catheter is going to be left in place, any catheter will serve the purpose, but when possible, a larger size, No. 7 or No. 8, would be better for maintaining perfect drainage. Two or three catheters in one ureter have definite value. Papin, Volker, and Bumpus have shown the benefit in abdominal pain, or renal colic, when it is caused by stone in the ureter, because the catheter will serve to push the stone back into the kidney pelvis thereby securing a normal drainage and the cessation of pain, allowing at the same time a dilatation of the lumen of the ureter which will aid later in the passage of the urinary calculi into the bladder. Sometimes when the stone is in the intramural ureter, the torsion of the catheters will serve as a net and in pulling out the catheters the stone may also come out. Then the patient may void the stone at urination, but if not, it may be easily removed from the bladder by cystoscopic manipulations.

The surprising benefit resulting from the use of an indwelling ureteral catheter in ureteral lithiasis is one of the outstanding achievements of modern urological surgery. Besides making passage of ureteral stones it usually drains the kidney relieving it from back pressure and infection.

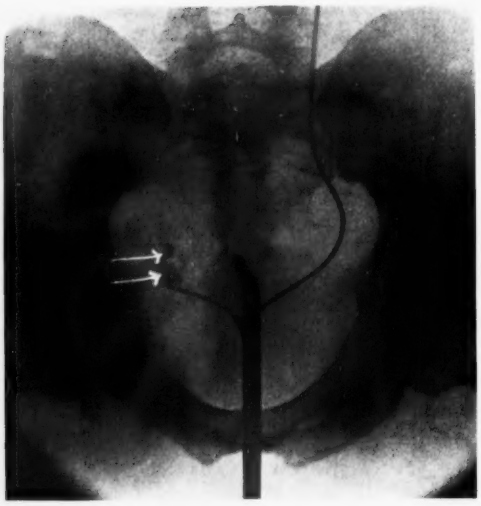


Fig. 4. X-ray picture showing the value of the indwelling ureteral catheter, as a means of diagnosis, demonstrating that the two shadows in the ureter correspond with the shadow of the catheter.

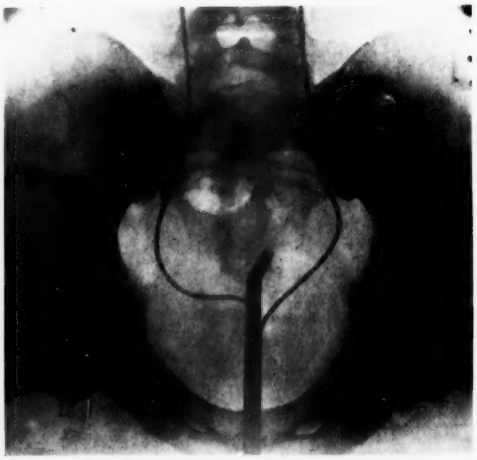


Fig. 5. X-ray picture of the same case, showing beneficial results of the indwelling ureteral catheter, which served to dilate the ureter and facilitated the passage of the stone.

The catheter should be left in place for one hour or one day, indefinitely, but the average time is from 3 to 7 days, if required. It is essential that irrigation be done at least three times daily with a mild antiseptic solution, in order to prevent the blockage of the catheter with blood or pus, to reduce the kidney infection, and to maintain a perfect drainage.

Albarran devised a special kind of ureteral catheter, tunnel type in form with an open end, to be used as an indwelling catheter, so that later, when it becomes soft and does not serve the purpose of securing drainage, a long thin catheter attached to a bougie (as an urethral filiform is attached to the tip of a sound) could be passed through it and left in its place, removing the first one without submitting the patient to further cystoscopy. But, in these days, it is not commonly used, due perhaps to the diversified improved cystoscopes, which facilitate painless procedure.

The contra-indications to an indwelling ureteral catheter are the same as those to cystoscopy. The urethra must be permeable and without actual acute or chronic infection or veritable discharge. The catheter should be removed or replaced in certain instances when necessary, but it should be definitely taken out when it causes discomfort or pain to the patient and in cases of chill or high temperature.

It is well to remark that there is no definite rule governing the principle of the indwelling ureteral catheter, because each case is a law unto itself and clinically or surgically should be treated according to its own requirements. Not long since ureterotomy for stone was a common operation in urinary surgery, but in these days it has become rather rare in view of the fact that 90 per cent of all small and medium sized stones of the ureter and kidney pelvis diagnosed, are passed by means of an indwelling ureteral catheter or by dilatation with bougies of ureteral cystoscopic manipulations.

It is wise at this time to emphasize the principles relating to the formation and reformation of stone in the urinary tract, because the laity believed for a time that urinary calculi are dissolved by internal medication and passed out. This theory should by no means be considered, because stones in the urinary tract, whenever found, are eliminated only by spontaneous passage at micturition, when they do not encounter any mechanical obstruction, or by removal at operation when

they have grown too large to pass through even with the aid of the indwelling ureteral catheter or by cystoscopic manipulations.

The etiological study of the formation of urinary calculi is as ancient as the history of medicine and still remains much in the dark notwithstanding the many theories advanced, plus the vast experimental work that has been done recently on animals. But with the new methods of diagnosis at our disposal in modern urology we have come to the conclusion that in the great majority of cases infection plus lack of normal drainage due to pathological conditions of the excretory upper urinary system, has been the chief etiological factor not only of urinary stasis but in many instances of formation of a nucleus for veritable urinary calculi. As a rule outside of the silent stone in the kidney parenchyma infection is always present and plays a definite rôle. Therefore, the securing of drainage will remain as the paramount and most essential of all treatments, as it is to a sound prognosis.

Many of the so-called cases of pyelitis and pyelonephritis, with obscure abdominal symptoms and gastro-intestinal disturbances characterized perhaps by only microscopic hæmaturia or a few pus cells in the urine, have proved to be the result of infection in the kidney pelvis, due mainly to retention of urine or faulty elimination, and it has been our experience to see a great number of these cases in our clinic in which the infection, diminution in function, and the positive culture for many micro-organisms have cleared up by means of routine treatment of dilatation of the ureters and kidney pelvic lavage, or the so-called indwelling or fixed ureteral catheter, which serves to obtain perfect drainage.

Indeed, the future in urological surgery rests definitely on the correction of infection and the maintenance of function.

In this last decade, the continued progress in modern urological diagnosis has secured a new method of examination, which has made it possible to predict the prognosis in certain cases when controlled by pyeloscopic studies. The Necker school has emphasized its value in detecting through the fluoroscopic screen, the physiological contractions and movements in the filling and emptying of the kidney pelvis,

Fig. 6. This picture shows the combined use of roentgenography, opaque X-ray ureteral catheter, and pyelography, in relation to diagnosis of anomalies in the upper urinary tract. It illustrates beautifully a fused kidney, which lies in the right side of the ower abdomen, and which, without this method of examination, could easily be confused with an abdominal tumor.

obtaining thus a vivid view of the elimination time of the urine from the kidney, as it has been for years known in regard to the fluoroscopic study of the gastro-intestinal tract.

The normal kidney pelvis injected through the catheterized ureter with the opaque medium of sodium iodide, empties its contents, physiologically speaking, in from 5 to 7 minutes, and whenever its contraction in emptying is slow or retarded, urinary stagnation with tendency to develop infection, or hydronephrosis or pyohydronephrosis is consequently, in many instances, a common occurrence. Lack of normal drainage or retention in the kidney pelvis may be detected by pyeloscopy; this condition can also be detected by taking a third or fourth plate or roentgenograms in series 10 minutes after the pyelogram and ureterogram are made. This method will serve to reveal much unknown and overlooked kidney pathology and will demonstrate at the same time that the placing

Fig. 7. Bilateral double kidney and double ureter, diagnosed cystoscopically, roentgenographically, and pyelographically, showing kink in the ureter and urinary stasis plus infection which was successfully treated with indwelling ureteral catheter. (Kirwin's case.)

of the fixed catheter is of great practical value, because it serves to secure drainage from the kidney pelvis of the retained sodium iodide and will prevent the reactions after pyelography, such as kidney pain and more or less discomfort, until the medium is absorbed or eliminated.

The indwelling catheter after pyelography is, therefore, highly desirable, because it will serve to permit the suction of the opaque medium, also lavage of the kidney pelvis, thereby relieving pain and maintaining perfect drainage.

I shall describe a few cases which I have had the good fortune to encounter in my own practice and which will serve to illustrate the routine procedure used in the three groups described in the three accompanying tables, wherein is briefly explained the incidence of the value and use of the indwelling ureteral catheter.

CASE 1. Value of indwelling ureteral catheter in the diagnosis and treatment of infected horseshoe kidney.

D. S., male, 18 years old, poorly nourished, appeared acutely ill, very pale, feeble, with a blood pressure of 108–60. He had been sick in bed for the last 2 months, before he was brought into The New York Hospital. He consulted me on October 15, 1928, complaining of pain across the lower back, with dysuria, marked pyuria, nausea, vomiting, headache, and high temperature. The family history and the past personal history are irrelevant except that he had an attack of malaria 9 years previously and had been suffering with chronic constipation all his life; also for many years he had pain in the back particularly radiating to both lumbar regions. Slight frequency of urination both during the day and at night had persisted for many years and was more troublesome whenever he caught cold. On arrival at the hospital, cystoscopy was done, with a functional renal test and a pyelogram of the right side, revealing the presence of a horseshoe kidney with pyelitis and pyelonephritic infection. The ureteral catheters were inserted into the kidney pelvis in order to secure drainage and for the purpose of irrigation. The patient was put on forced fluids, having as medication methylene blue and quinine sulphate three times daily internally. Also 1,000 cubic centimeters of saline intravenous infusion was administered daily and high colonic irrigation was also instituted. The patient's temperature ran from 101 to 103 degrees for 7 days, although his general condition was much improved and he was able to take food and to eliminate large quantities of urine. His blood chemistry was higher than normal and the Wassermann test was negative. On the eighth day, another cystoscopy was performed, when a pyelogram of the left side was made, showing the calyces of the kidney pelvis also pointing inwardly and, therefore, proving the presence of a fused horseshoe kidney. A slight degree of hydronephrosis, with lack of drainage and infection, was also detected. The catheters were reinserted and left fixed in place. The sodium iodide was suctioned and the kidney pelvis irrigated with plain distilled water. This was followed with an irrigation of the kidney pelves with a solution of acriflavine 1:10,000. The patient gradually improved, the temperature came down to normal, and he left the hospital on November 1, 1928, with the diagnosis of infected horseshoe kidney, for which he was advised to return for further treatment, consisting of dilatation of the ureters and kidney pelvic lavage. This treatment has been carried out at intervals of 2 weeks on several occasions, and this patient, at the present time, is free from symptoms, and his urine is clear. He is generally improved, has gained in weight, and has resumed his occupation. However, the patient has been advised that if this pathological condition of the kidney persists in troubling him, it will be necessary to consider a symphysiotomy operation in order to separate the fusion of the kidney parenchyma from its isthmus.

This case shows the value of an indwelling ureteral catheter both in regard to diagnosis, when combined with pyelography, and in

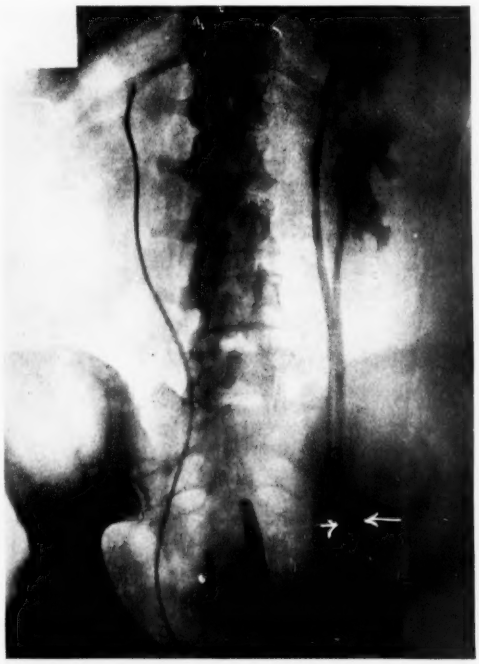


Fig. 8. This case illustrates the value of the ureterogram for detecting pathological anomalies of the ureter. With the patient in the erect posture, the catheter is withdrawn, and at the same time the sodium iodide is injected. This case shows a double kidney pelvis and a double ureter, with the ureters united before reaching the bladder, and therefore showing cystoscopically a normal bladder, with normal ureteral orifices. This condition could not be detected without this routine examination.

obtaining satisfactory results in the treatment of such cases when there is an infection and lack of proper drainage.

CASE 2. Use of the indwelling ureteral catheter during nephrectomy for calculous pyohydronephrosis.

Miss L. D., 18 years old, born in Scotland, came to the female clinic of the Urological Department of the New York Hospital on December 24, 1928, complaining of pain in the right kidney region of over 1 year's duration. She suffered from frequency of urination and nocturia, four to five times, and pyuria and dysuria. Her previous history was irrelevant. Menstruation started at the age of 12 and was always regular. The symptoms and urinary complaint were getting worse and produced fatigue and constant pain in the right lumbar region, radiating along the ureter down to the right quadrant. The patient was cystoscoped and the bladder mucosa throughout was found to be slightly congested, but otherwise of

Fig. 9. Case 2. Pyelo-ureterogram showing a rectangular calculus, blocking the injection of the opaque medium at the ureteral pelvic junction. On the left side, three distinct extra-urinary shadows, due to calcified lymph nodes.

normal appearance. On catherization of the ureters, specimens were collected from the left side and none was obtained from the right. The functional tests showed that the left kidney was within normal limits. There was secreted urea 15 grams per liter and the time of appearance of the dye after the phenolsulphonephthalein injection was 3 minutes with 10 per cent concentration. The culture was negative, but the culture of the urine from the bladder showed bacillus coli communis. The patient returned a week later when another cystoscopy was performed and a specimen was sent to the laboratory for a guinea pig inoculation. Also plain pictures and a right pyelogram were taken, revealing a rectangular shadow, apparently in the pelvis of the right kidney at the point of the ureteropelvic junction, therefore blocking the normal drainage of the organ. The left kidney shadow was normal in size and in good position and there could be seen three small, round shadows apparently in the contour of the left kidney but extra-urinary, and, therefore, probably calcified lymph nodes. The right pyelogram showed almost a complete blockage of the right pelvis by the stone, so that none of the sodium iodide entered the pelvis, but ran down the right ureter, which is apparently within normal limits. The impression gained was that of a rectangular stone in the right kidney pelvis and it was suggested that the stone be removed under regional anæsthesia. The patient entered

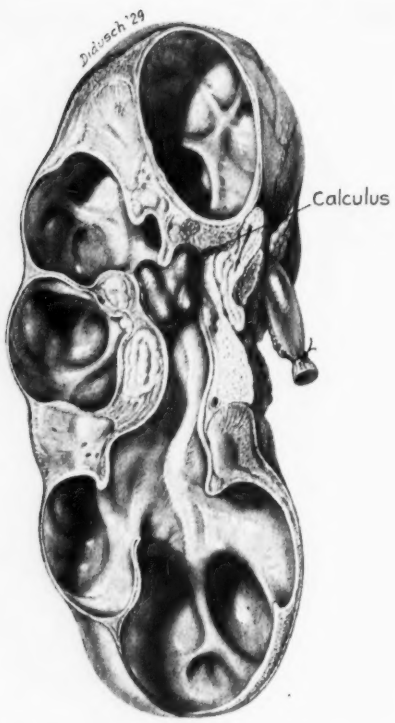


Fig. 10. Case 2. Drawing of specimen removed at operation showing the rectangular calculus which had blocked the normal drainage of the kidney and produced the distortion of the whole organ, ending in the formation of pyohydronephrosis.

the hospital on February 17, 1929. In this case the patient was cystoscoped before the operation, the right ureter being catheterized with a No. 6 French catheter which was left fixed *in situ* during the operation, with the purpose of facilitating the surgical procedure and readily exposing the ureter. At the operation, when the kidney was exposed, it was found to be a shell, or a definite pyohydronephrosis, with complete distortion of the whole kidney parenchyma, and was functionless. Therefore, nephrectomy was performed. After a most satisfactory surgical exposure the catheter was pulled out by an assistant and then the ureter was clamped, cut, and tied in the usual manner. The kidney was removed, the pedicle was tied, and the wound was closed with small cigarette drainage. Patient made an uneventful recovery and returned home in 2 weeks, with the nephrectomized wound closed and practically free from urinary symptoms.

CASE 3. Bilateral renal lithiasis. Right pyelotomy, and one year later nephrotomy for removal of calculi. Uneventful recovery. The value of the indwelling catheters in this case is correcting infection and securing drainage.

S. A., an Italian woman, 50 years of age, came into the female clinic of the Department of Urology of the New York Hospital, March 23, 1928, complaining of pain in the right upper quadrant for the past 2½ years, with slight frequency of urination and marked nocturia. Urinalysis showed considerable pus. The patient was submitted to complete urological examination. On cystoscopy examination, the bladder was found to be very much congested throughout, both ureters were catheterized, and the functional test was quite diminished on both sides. An X-ray picture was taken with the catheters and the instrument fixed in position, and showed two enormous shadows in the area of both kidney regions. Therefore, a diagnosis of bilateral nephrolithiasis was made. The right kidney having much better function than the left, the patient was admitted to the hospital and pyelotomy for removal of the stone on the right side was done. The patient had an uneventful convalescence and the lumbar wound was firmly healed. But on the seventh day of the operation, she developed pain on the side of the operation and it was easy to palpate a fairly big distended right kidney. She was running a temperature from normal up to 102 degrees. The patient was then cystoscoped and on catherization of the right ureter, a considerable amount of thick green pus was obtained. The catheter was left in place and the kidney pelvis was irrigated with acriflavine 1:1,000, several times. The catheter was removed in 48 hours and the patient was submitted to another cystoscopy 3 days later, when much purulent urine was still suctioned from the kidney pelvis. The catheter was left in place for several hours in order to secure drainage and to irrigate the kidney pelvis. The patient's temperature came down to normal and she left the hospital on April 13, 1928, when I advised her to return to the clinic, where she received weekly cystoscopic treatments with kidney pelvic lavage for several months. The infection subsided and she was sent to the country in order to build up resistance for the second operation. Six months later upon her return her general condition was greatly improved, but she was still suffering with a dull pain in both kidney regions and frequency of urination. Cystoscopy and renal tests were made again showing that functional tests in regard to urea secretion and time of appearance of the phenolsulphonephthalein were very much improved. A summary of the past history of the case is of interest and shows that on October 31, 1928, the phenolsulphonephthalein test showed secretion 0.05 per cent in 10 minutes on the right side, and 3 per cent on the left side. Cultures from right and left ureters showed bacillus coli communis. An X-ray of the genito-urinary tract taken on February 15, 1929, showed the left kidney shadow to be large in size and in fair position, and the entire pelvis was filled with calculi. On March 26, 1929, the kidney function was still markedly diminished. A cystoscopic

Fig. 11. Case 3. Bilateral renal lithiasis showing the opaque ureteral catheter in contact with the renal calculi.

examination was again made. The specimen obtained from right ureter was clear and showed 10 grams of urea per liter while specimen obtained from the left side was cloudy and showed 4.5 grams of urea per liter. One cubic centimeter of phenolsulphonephthalein injected intravenously appeared on right side in 4 minutes and on left side in 4.5 minutes. The phenolsulphonephthalein test showed secretion on the right side 8 per cent in 10 minutes and 2 per cent on the left side. Microscopical examination of the urine from the left kidney showed it to be loaded with pus cells. However, her general condition was much improved; the patient had gained 22 pounds in weight and as her kidney function and blood chemistry were better, it was suggested that the stone that occupied the complete left pelvis be removed by nephrotomy.

The patient was re-admitted to the hospital on March 18, 1929, and under paravertebral anæsthesia, nephrotomy was performed, and the large stone from the left kidney was removed successfully. During the operation, the kidney was found to be quite large, it contained pus, but the parenchyma still appeared to be in good condition, and therefore sufficient to maintain satisfactory function. The patient had an uneventful recovery, and left the hospital 16 days after operation with a small lumbar sinus, but in very good condition.

It is of interest to remark in this case how, by simple cystoscopic treatments with catheterization of the ureters and kidney pelvic lavage, and the method of the indwelling catheter, this patient steadily improved, and notwithstanding the urinary complaints and infection caused by the stones in the kidney pelvis, her general health improved with this treatment, and thus we could perform successfully the two operations for the removal of the offending stones. The first operation was done by me March 23, 1928, and the second one was done by Dr. Lowsley, one year later, in March, 1929. The two operations, pyelotomy and nephrotomy, were carried out in order to remove the bilateral kidney stone, paravertebral anæsthesia being used under which the patient did exceedingly well. She made a complete recovery.

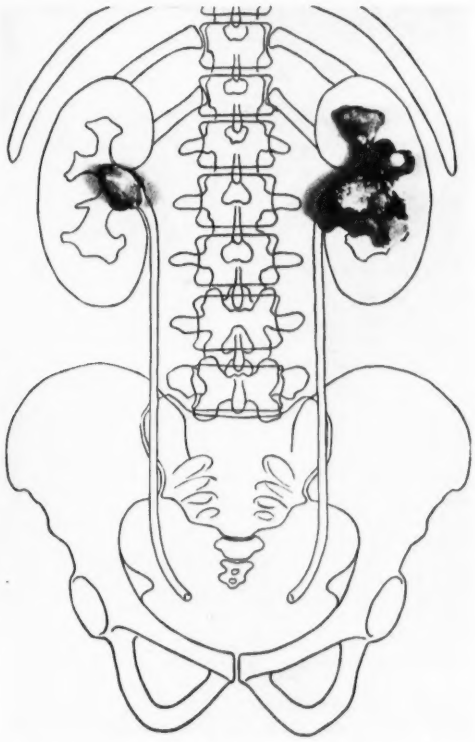


Fig. 12. Case 3. Actual size of the two kidney stones removed at operation.

CASE 4. Value of fixed ureteral catheter after nephrectomy for renal tuberculosis in an attempt to aid the healing of the lumbar wound.

Fig. 13. Case 4. Right pyelogram of a tuberculous kidney, showing a completely distorted and functionless organ.

Fig. 14. Case 4. Pyelogram taken of the kidney specimen removed at operation, showing complete distortion of the organ with very little parenchyma remaining, verifying the diagnosis of kidney tuberculosis.

S. L., History No. 157480, an Italian woman, 45 years of age, married, came to the female clinic of the urological department of the New York Hospital on August 2, 1928, complaining of pain in the right lumbar region, intermittent hæmaturia for 1½ years. She suffered from marked pyuria with pain and burning at urination; also frequency during the day and at night, as often as every half hour during the day and several times at night. Patient was submitted to complete urological examination. On cystoscopy, a definite ulcer involving the mouth of the right ureteral orifice was detected. As the patient had a very poor bladder capacity and complained of pain, catheterization of the ureters was not made. She was submitted to bladder lavage and methylene blue was given. Two weeks later, another cystoscopy was done, with catheterization of both ureters. This examination showed that the left kidney had good function and that from the right side no specimen of urine could be obtained. Even after injecting a few cubic centimeters of water no dye was eliminated. Pyelogram of the right side was taken showing a greatly excavated kidney, giving the impression of a tuberculous pyonephrosis. The patient was submitted to the hospital for operation September 13, 1928, and a right nephrectomy was performed under paravertebral anæsthesia. The patient left the hospital October 22, 1928, with a small lumbar sinus which discharged purulent urine, for which she was treated, in the anti-tuberculous clinic, with anti-tuberculin and light treatment. She also had a few cystoscopic treatments, with irrigations of the stump ureter with a solution of rivanol dextrose 1:2,000, and on several occasions, the ureteral catheter was left fixed in place to secure drainage and to allow the lumbar wound to heal. Also, the ulcer seen at the mouth of the ureteral orifice was fulgurated with an electrode on two different occasions. The patient's wound healed up entirely, as well as the tuberculous ulcer of the bladder, and she made a complete recovery. Six months after the operation the patient had gained over 60 pounds in weight, and her general condition was excellent and she was entirely free from urinary symptoms.

In this case the fixed catheter aided in the healing of the wound, securing drainage, relieving infection, and hastening the complete closure of the wound thus effecting a permanent cure.

Case 5. Ureterotomy for impacted stone in an anomalous ureter. Value of the indwelling ureteral catheter during operation to corroborate diagnosis, to discover anomalies encountered at operation, and to facilitate safe surgical procedure. Case of double ureter containing stone where urography did not reveal the condition found at operation.

Fig. 15. Case 5. Plain X-ray plate showing the value of the ureteral catheter in diagnosis when the shadow of the stone in the ureter corresponds with the shadow of the catheter.

Fig. 16. Case 5. Picture shows the Kretschmer double exposure to determine that the shadow of the urinary calculus corresponds with the shadow of the catheter.

P. T., an Italian woman, aged 55 years, married, was admitted to the medical ward of the New York Hospital on June 13, 1928. The diagnosis was acute pyelitis, nephrolithiasis, and diabetes mellitus. The patient was submitted to numerous cystoscopic examinations that apparently relieved her condition and she was readmitted to the medical ward a few days later, complaining of pain in the right lower quadrant, accompanied with chills and bladder symptoms, with marked pyuria and frequency of urination. The interesting feature in this case is that while she had the first cystoscopic examination and pyelogram made, the diagnosis of stone at the ureteropelvic junction was made, and this patient was submitted to further cystoscopic treatments for dilatations of the ureter and kidney pelvis lavage for the purpose of allowing the passage of the stone and to correct infection. In subsequent examinations, the shadow of the stone in the X-ray plates was found to be at the ureteropelvic junction, apparently impacted in that portion of the ureter and being the cause of the retention which produced the presence of acute infection in the right kidney. A plain X-ray picture with the catheter in position and with the Kretschmer double exposure, showed a definite shadow of urinary calculi in the upper portion of the right ureter, just above the transverse process of the third lumbar vertebra. This point was beautifully corroborated by the filling defect at that point in the pyelogram. As the patient was submitted to numerous cystoscopic treatments and kidney pelvic lavage in the genito-urinary clinic of the New York Hospital and did not pass the stone, but developed high fever, tender kidney, and acute renal condition, operation for the removal of the stone was advised. The patient entered the hospital and ureterotomy for the removal of an impacted stone of the right ureter was performed on December 14, 1928, under paravertebral anæsthesia. Before the operation the patient was put in the lithotomy position on the table and cystoscoped without difficulty. A large No. 7 ureteral catheter was passed up to the pelvis of the right kidney and allowed to remain. The cystoscope was then withdrawn, and the patient was put on the table in the usual position for a kidney operation. It was striking to find, during the operation, that the catheterized ureter was readily exposed and that there was not any urinary calculus found in this catheterized ureter. Then search for an extra-anomalous ureter was made and a supernumerary ureter containing an impacted stone was found. This anomalous ureter ran from the upper portion of the pelvis of the kidney, down about one-half the way to the bladder, uniting with the ureter

Fig. 17. Case 5. Pyelogram showing a filling defect at the ureteropelvic junction, or upper portion of the ureter, where the shadow of the calculus was seen in the plain picture. In this case the ureterogram was not taken, thus failing to reveal the anomaly of an extra ureter containing the calculus which was discovered at operation, while having the ureteral catheter fixed in place.

Fig. 18. Technique of operation in Case 5 showing the value of the indwelling ureteral catheter during operation. The catheterized ureter is readily identified but no stone was found in the ureter and on further dissection an extra ureter was discovered containing the impacted stone which was successfully removed by ureterotomy. The two patent ureters united before they reached the bladder and urography did not reveal the condition. This pre-operative procedure of fixing the ureteral catheter *in situ* has proved to be most helpful and satisfactory.

which was previously catheterized about the middle of the iliac vessels. The indwelling ureteral catheter during operation proved to be of great assistance in detecting this anomalous condition of the ureter, not revealed by the pyelo-ureterogram, and it facilitates the surgical procedure in a most satisfactory manner.

The ureter was incised and the stone was removed in the usual manner, the lumbar wound being closed in layers. The patient had an uneventful recovery. The wound healed by primary intention and the patient left the hospital in 14 days, in excellent condition.

SUMMARY

The indwelling ureteral catheter is the most valuable adjunct in urological surgery. Its clinical results obtained in selected cases are most gratifying, but always of paramount importance is correct diagnosis before establishing the proper treatment, because it is obvious that no treatment will ever be adequate if the clinical entity has not been recognized.

In acute clinical conditions, likewise in calculous anuria, if the indwelling ureteral catheter fails to relieve the alarming symptoms, surgical intervention should not be delayed (Case 5). The life of our patients could be saved by any operative procedure upon the kidney or ureter in an attempt to remove the obstructing calculus and to secure urinary drainage.

One of the most common incidents in the pathology of nephrolithiasis or ureterolithiasis, is the calculous anuria or suppression of urine toward the formation of uronephrosis and fatal uræmia, and the statistics have shown evidence of the gravity of this condition. It has been proved also by many authors that the early operative intervention gives better

results, for instance: Watson and Cunningham, in an analysis of 205 cases of calculous anuria, in which a group of 110 such cases were treated expectantly, reported deaths in 80 cases, a mortality of 72.7 per cent, and in another group of 95 cases, treated operatively, reported deaths in only 44 cases, a mortality rate of 46.3 per cent. Therefore, while many of these cases could have been treated satisfactorily with the method of the indwelling catheter as recently emphasized by Marion and Heitz-Boyer, Papin, Beer, Eisendrath, and other writers, at the same time one should not wait too long because if relief from symptoms is not obtained in a reasonable length of time, surgical intervention is the operation of choice. In other words, the indwelling ureteral catheter is not a panacea for all pathological conditions of the upper urinary tract. Nor should operative intervention, when required, be delayed. Moreover, it is obvious that the diagnosis must be accurate and definitely clear, because besides a few contra-indications this method should not be used in cases of extrarenal or intrarenal conditions of the kidney when the pathological process has become well advanced or does not communicate with the excretory apparatus of the organ, as in the case of perinephritic abscess, cortical abscess of the kidney, or well advanced renal tuberculosis or hypernephroma of the kidney, when surgical relief must remain as the most imperative hope of cure.

CONCLUSIONS

1. The indwelling ureteral catheter is of value in urinary surgery, not only in regard to diagnosis and treatment but as a convenience during and after operation.

2. The empiric classification of the three groups in the three accompanying tables is made only for the purpose of popularizing a practical procedure, which deserves a wide application.

3. The catheter to be used is preferably a No. 6, No. 7, or No. 8. It should be an X-ray catheter because this type is more durable, more flexible, and produces less discomfort.

4. It is essential that the catheter must serve its purpose, that is secure drainage, relieve pain, and correct infection.

5. The fixed catheter should be irrigated at least three times daily, with a mild antiseptic solution, as boric acid or acriflavine 1:10,000. Also, in certain cases, when possible, two catheters in the same ureter and continuous irrigation may be definitely indicated.

6. The catheter should be left fixed in place for a period of days or even weeks, until symptoms are relieved or as long as necessary.

7. In leaving the indwelling ureteral catheter *in situ*, in certain cases in which there is marked infection of the bladder or in which the bladder does not empty properly, it will be advisable to use a retentive urethral rubber catheter with the double purpose of securing drainage of the infected urine, indefinitely, both from the kidney pelvis and from the bladder. When this double drainage is required, the urethral catheter should be easily passed, it being inserted through the inlying ureteral catheter.

8. During operation, the fixed ureteral catheter is the best guide to the surgeon. It affords ready exposure of the ureter and facilitates any surgical procedure upon the kidney pedicle.

9. The most striking results are obtained with this method of treatment in "renal colic," ureteral calculi, pyelitis and pyelonephritis, the so-called idiopathic hæmaturia, urinary stasis with or without infection, and in calculous anuria. Also in certain instances when elimination of urine is insufficient, forced fluid and daily intravenous infusion are highly desirable.

10. After operation, it will serve to secure drainage and prompt healing of the wound, without leakage of urine or the formation of permanent fistula.

11. Also, after operation, it will serve, too, to divert the urine from the bladder, particularly in operations on vesicovaginal fistulæ, thus permitting the bladder to heal without infection from the urine.

12. The technique of the indwelling ureteral catheter is merely that of cystoscopy and catheterization of the ureters and to accomplish it, it does not require more than a working knowledge of these methods by the urologist.

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CLINICAL SURGERY

FROM THE SURGICAL CLINIC OF ST. VINCENT'S HOSPITAL, MELBOURNE

ABDOMINAL TECHNIQUE—A SYSTEM OF OPERATIVE EXPOSURES

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ADEQUATE exposure is the great secret of success in the performance of abdominal operations. It should be such that the surgeon is able to dissect or carry out any manipulations in the particular operation field under perfect sight, that he is undisturbed and unhampered by the neighboring viscera, and that the organ or organs on which he is operating are, as far as possible, under normal physiological conditions.

It is, of course, a common and traditional practice during the progress of an operation on an organ, to drag it out of the abdominal cavity; such a procedure does not constitute a truly scientific exposure. The proper way is to isolate, expose, and operate on the organ while it is *in situ*, that is, while it is in the abdominal cavity where it is naturally kept warm and moist. In these circumstances there is no necessity to handle bowel or to drag on mesenteries, both of which are richly supplied with shock-susceptible splanchnic nerves. It is perhaps not sufficiently realized what a big factor unnecessary interference with physiological conditions during an operation is in producing shock and inducing inhibition of the movements of the alimentary canal. This has often been signally apparent to us when operating on the abdomen under local anæsthesia. It has been remarkable to see the distinct change in the patient's general condition if much visceral dragging or handling becomes necessary, although no pain is produced. On the other hand, while manipulations on a poorly anæsthetized abdominal wall give rise to pain they have almost a good effect on the patient's general condition.

Many years ago, having these basic considerations in mind, we evolved a system of abdominal technique, the exordium of which was woven round a rather crude mechanical retractor, designed so that these and other desired principles in abdominal technique might be carried out. It was originally an expedient to render possible certain extremely difficult, practically impossible, secondary gastric and gall-bladder operations. This clean, definite, standardized method of operating gradually forced itself by its very potentiality and usefulness into our technique in other abdominal fields. We soon found that it made abdominal operating easier and quicker; so that if it did nothing else, it minimized anæsthesia and lessened shock to the patient. Also, it saved strain and conserved the energy of the operator.

The keystone of the technique is a gentle, evenly distributed, unvarying, protecting instrumental retraction and control of the abdominal wound and wall. Principles concerned in this technique and attained by and embodied in the use of this retractor are:

1. Effective wound protection from trauma and infection.

2. Control of the anterior abdominal wall, so that it can be lifted away from the viscera, thus creating a space for (a) operative manipulation; (b) exploration; (c) the easy replacement of intestines; and (d) the toilet of the peritoneum of the anterior abdominal wall.

3. Isolation of the organ to be operated on by complete instrumental exclusion of the intestines from the area of operation.

4. Systematic "guy-rope" anchoring of hollow viscera to the frame, enabling gastric or intestinal suturing to be carried out against constant tension with great precision, exactitude, and neatness.

5. A ratchet "spreader" action enabling the retractor to be used for the surgical approach to the kidney, lung, bladder, etc.

We soon found that an extraordinarily light anæsthesia was possible because the anterior abdominal parietes were not constantly being handled, and because once the retractor and its "mechanical hands" were "set," great relaxation was not a consideration.

Difficulties in suturing the abdominal wound also disappeared, probably because the light but

Fig. 1. Four-bladed abdominal retractor. *1* and *2*, two slotted *L* pieces which dovetail into each other; *3*, sliding bar which moves on *1* and *2* by ratchet action; *I*, *B*, and *T*, double hooks for retractors; *A*, *C*, *H*, *J*, *K*, and *O*, single hooks for attaching "mechanical hands." All these lock the retractors and "mechanical hands" by a jamming action on the frame because they work on a series of inclined planes.

continuous pressure of the retractor fatigued the abdominal muscles.

The results, both immediate and remote, were exceedingly good, for this method of operating demanded and developed a special type of desirable operative skill, that is, accurate, detailed, dry dissections under good vision with long, very sharp instruments—really an ideal technique.

That this meticulous and precise method was justified was demonstrated by observations in any secondary operations after this technique. These revealed a remarkable absence of adhesions, and some abdomens looked as if they had never been opened before. Since the adoption of this technique, wound infection has been almost unknown to us. Perhaps the most noticeable thing, certainly from the patient's point of view, is the placid postoperative course, the absence of any definite "after-treatment" period. Indeed, the sisters have often volunteered the information that the patients operated on in this way may be distinguished by the remarkably little after-treatment they need. We have often demonstrated that, intelligently used, the retractor never in the least degree traumatizes the wound.

In the light of the foregoing, it is difficult for us to understand why some surgeons still have a prejudice against the use of proper instrumental retraction; why they prefer to draw the viscera out of the abdominal cavity where they are kept warm and moist; and why they should really make difficulties, as, for instance, by operating in an area which is inadequately lighted, because their own and their assistant's hands are in the light, and because the crowding-in of the intestines and of the wound edges prevents the access of natural light to the part.

THE RETRACTOR

The retractor has been redesigned in the light of ten years' experience, and is here illustrated for the first time, Figure 1. It consists of two slotted L pieces, *1* and *2*, which dovetail into each other; a sliding bar, *3*, which moves on *1* and *2* by a ratchet action; four retractors (*1*, *2*, *3*, and *4*, Fig. 2) for clasping the abdominal wound; a system of "mechanical hands" (*5*, *6*, *7*, *8*, and *9*, Figs. 2 and 3 with detachable blades of different shapes and angles, Fig. 4).

The instrument is so designed that there are no screws, yet the retractors and "mechanical hands" by a jamming action remain firmly on the frame in whatever position they are placed. This is accomplished by a system of inclined planes incorporated in the frame and in the single hooks (*H*, *K*, *U*, *O*, *L*) and double hooks (*B*, *Q*, *N*, *I*) in Figure 2 and in the retractor and handles of the "mechanical hands."

When the "mechanical hands" are inserted, it is particularly necessary to note that they are always at first loosely fixed on the single hook at *C* (Fig. 5) or a point corresponding to it, that is, with the handle at right angles and near the center of the bar. A firm lateral movement to *L1* (Fig. 5) will now tighten and jam the "hand" as the side *L1–L2* is longer than the side *C1–C2*.

Except for the frame and "mechanical hands," the retractors used belong as a rule to the armamentarium of any surgeon.

"SETTING" THE OPERATION FIELD

The field of operation should be set deliberately as a stage of the operation. It is better to make a somewhat smaller incision than usual in order to get the spring-like action of the muscle. It is this that really retains the retractor firmly in position and gives the frame its lifting purchase on the abdominal wall; if this lifting purchase is intelligently cultivated and used, it becomes extraordinarily useful in abdominal operating.

If there are no adhesions to the abdominal wall, as a first step the retractor should be introduced and fixed as follows:

Two very thick towels or two specially made sheets of rough glove rubber, 15 inches by 12

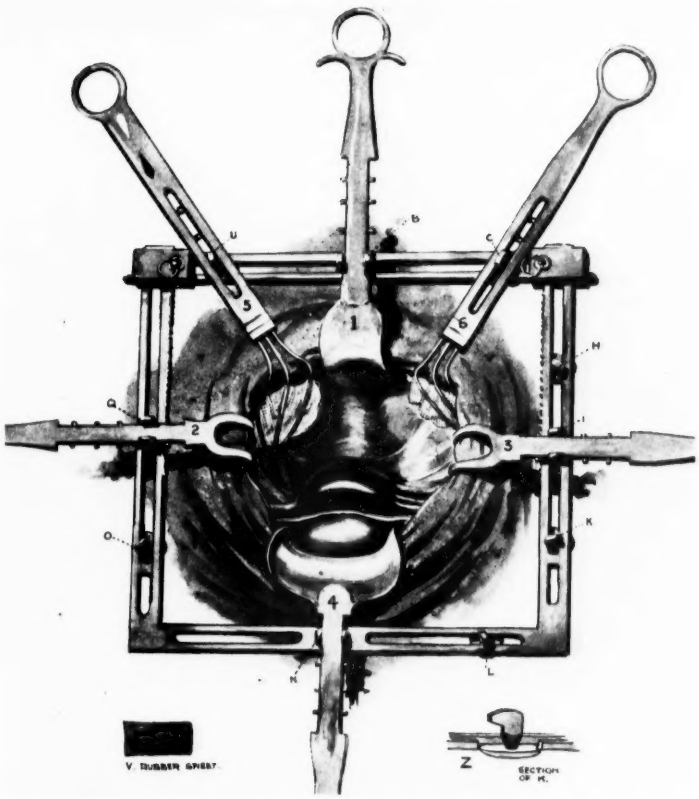

Fig. 2. Retractor set for a pelvic operation. The incision is in the lower part of the abdominal wall. The edges of the wound are covered with rough glove rubber. "Mechanical hands" *5* and *6*, with a soft scarf acting as a buffer, keep the intestines well out of the wound and well up into the abdominal cavity. The pelvis is empty except for the rectum, uterus, and its adnexa. *Z*, Section of a single hook to show how it jams and fixes the "mechanical hands."

inches (Fig. *2*) are laid over the wound so that they overlap its edges well. The frame is laid on these and if the wound is in the upper part of the abdominal wall (Fig. *3*), the left forefinger is placed on the towels at the lower angle of the incision where they are tucked well under the cut edge of the abdominal wall. Retractor *1* is now substituted for the finger and is held up by the left hand of the assistant so as to elevate the abdominal wall until it is clear of the viscera and thus enable the operator with his left hand at *C* to tuck the towel at this point well under the peritoneum and, unhampered by intestines, to insert retractor *2* and lock it on the frame. The assistant, using his right hand, pulls the frame toward him and keeps it on tension at the point *C* so that omentum or intestines cannot get under retractor *2*. He still retains the upward tension on retractor *1*. This facilitates the insertion and the locking of retractor *3*. Retractor *1* is now locked. The assistant with his hands at *E* and *G* now lifts the frame, enabling the towels to be easily turned under the peritoneum in the upper wound angle and permitting the insertion and locking of retractor *4*.

The wound now should be open to its fullest extent under slight tension only and the wound edges, including peritoneum, should be neatly covered so that there should be no fear of disarrangement, damage, or infection (Fig. *3*).

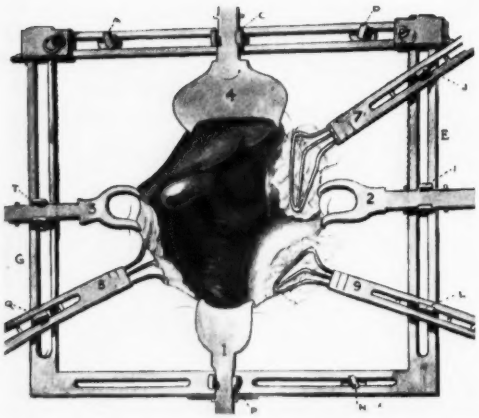

Fig. 3. Retractor "set" for an operation upon the gall bladder. The incision is in the upper part of the abdominal wall. The No. 1 broad Fritz retractor is put in the upper angle of the wound. "Mechanical hand" 9 has the most important function. It draws the duodenum (covered with a scarf) medially and stretches the common duct and draws the gall bladder toward the midline. "Mechanical hand" 8 keeps the hepatic flexure out of the way, and "mechanical hand" 7, a deep one (A, Fig. 4), is used to keep the stomach out of the way.

When the incision is in the lower part of the abdominal wall, retractor 1 is inserted first in the upper angle of the wound and the others in order of their numbers (Fig. 2).

When there are adhesions to the anterior abdominal wall, as in secondary abdominal operations, a second step will be necessary. Here it is better at the outset to choose or make on each side of the wound a space clear of adhesions. Into these spaces insert retractors 2 and 3 (Fig. 6), lock them on the frame, and with this lift the abdominal wall. The viscera will hang and it is an easy matter to put tension on the now well-lighted adhesions, thus facilitating what is usually a very difficult task—the neat disconnection of adhesions from the anterior abdominal wall, especially those far out from the incision.

When these adhesions have been divided, preferably with a long scissors, and the operation field is "set," then the abdominal wall is lifted away from the intestines by the gentle elevation of the frame. In this way a space is created through which the operator can explore the abdomen. As a matter of fact, much of the abdominal cavity can in this way even be inspected under good vision; certainly it can be explored comfortably because the exploring hand is not hampered and harassed by the intestines and the clinging omentum. It is also wise at this stage to see to the suturing of any wound made in the peritoneum of the anterior abdominal wall by the severance of adhesions. Lifting the abdominal wall away from the viscera enables this to be done with ease and accuracy, even though the wounds are far out under the wall—an essential precaution to prevent the recurrence of the pernicious parietal peritoneal adhesion.

EXCLUSION OF THE INTESTINES

The next step is to clear away the intestines, stomach, and any other viscera from the operation field and to incarcerate them under the abdominal wall. Here they will be free from injury and will be kept warm. This exclusion of intestines from the operation field by the use of "mechanical hands" is a very special feature in the technique, and is of great value when the organ is deeply situated and access is difficult, as, for instance, in the exposure of a contracted and highly situated gall bladder, or of the pancreas in a fat person, or of a kidney from the abdominal cavity. This maneuver is carried out by means of large soft veils of a single layer of gauze (a yard by a yard-and-a-half) puckered at one end, and "mechanical hands" with blades set at an acute angle. The method varies according to the particular operation field, but follows to a certain extent some general rules.

The veil is laid on the intestines and the frame (not the retractor) is lifted so that the veil tangled up with the intestines is drawn into the abdomen. Add several extra layers of the veil and with the hand draw the intestines far out under the abdominal wall. Substitute a "mechanical hand" for the hand and fix it to the frame. The crumpled-up "veil" acts as a buffer between the "mechanical hand" and the intestines. Do this on the sides of the frame where it is necessary, until the operation field is quite free from the intestines (Fig. 2, 5 and 6; Fig. 3, 7, 8, and 9). As the acute angled blades of the "mechanical hands" are so made that they fit well under the abdominal wall, there should, therefore, be no infringement by these on the operation area.

OPERATIVE EXPOSURES

Gall bladder. The precision, exactitude, and value of this technique is best seen in a difficult cholecystectomy. Indeed, no cholecystectomy can be difficult with it; at least, that has been our experience. There will be no accidents, such as injury to the common duct.

In the planning of the incision, the cystic duct must be regarded as the point of greatest importance—the keystone of the operation and the

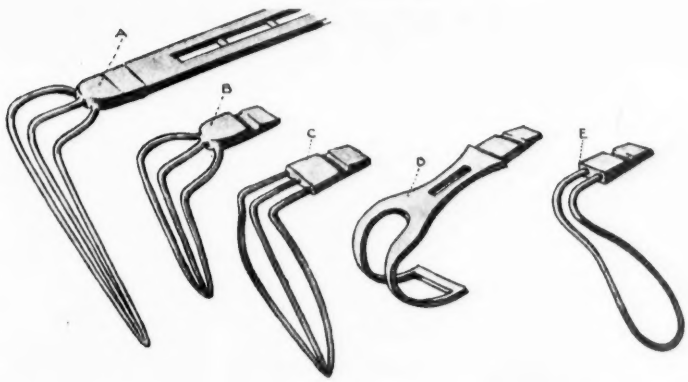

Fig. 4. Detachable blades for "mechanical hands." *A*, Long deep blade for special purposes; *B*, narrow shallow blade for difficult appendiceal operations and other purposes; *C*, blade used for gall bladder, pelvic, and other work; *D*, small blade for use in small wounds, such as for acute appendicitis, etc.; and *E*, blade for the urinary bladder.

main objective of the operative exposure. For this reason a paramedian incision must be used and made as high as possible. The retractor is now inserted and the wound set in the usual way. The next object is to stretch the gastrohepatic omentum and thus to unravel and straighten out the biliary vessels and ducts. To do this, three or four folds of a veil are laid loosely on the second part of the duodenum, and by means of a "mechanical hand" the spine and the surrounding intestines are drawn well over to the left under the abdominal wound. With other "mechanical hands" and scarves the stomach (use a deep "hand" for this as in Fig. 4 and Fig. 3, *7*) and the colon (Fig. 3, *8*) are drawn out of the way.

If the patient is now put in the reverse Trendelenburg position, the operation area will be flooded with light, and dissection of the cystic duct and the gall bladder will be possible under good vision. The exposure[1] is so perfect that it is quite unnecessary to touch or drag on the liver, and this means much less postoperative disturbance and nausea.

Common duct. While a good exposure of the common duct is necessary for the removal of gall stones, especially in fat people, it is of inestimable value in injuries to the common duct, which as a rule are due to some accident during a cholecystectomy and occur near the hepatic ducts—a situation very difficult for operative manipulation. The gall bladder and common duct are dissected free from any adhesions, and the operation wound is "set" as usual. It is wise in exposing the duct to stretch the duodenum downward, not over the spine, and to push up the liver. To do this it is necessary to use four "mechanical hands." Scarves and "mechanical hands" should, therefore, be used to retract out of the operation area (a) the stomach, (b) the hepatic flexure of the colon, (c) the duodenum and small intestines, (d) the liver edge upward. The important retraction is the lifting of the liver, thus stretching, opening up, and exposing the upper part of the common duct for dissection. So as not to injure the liver, it is necessary to use a small blade, with extra layers of the soft gauze, and light pressure.

The exposure obtained is surprisingly good; the operation area is "set" and does not require the annoying constant readjustment necessary in the usual methods. Certainly patience and deliberation are required, but these are amply repaid by the well lighted operation field and by the precision which is possible in the difficult manipulations of the suturing of the hepatic duct into the duodenum, or the suturing of a wound in the upper part of the common duct. Here, as in all operations on the gall bladder, if a dilated stomach is in the way, it is wise to deflate it with a trocar attached by rubber tubing to a suction pump (Fig. 7).

With this exposure it is also quite easy to dislocate the duodenum, to probe the common duct, and to examine the ampulla of Vater, or to carry out any precise dissections or manipulations necessary in this region.

Stomach. The œsophageal end of the lesser curvature of the stomach is the point of greatest

[1]This technique has been given in much greater detail in Surg., Gynec. & Obst., 1927, xliv, 85-89.

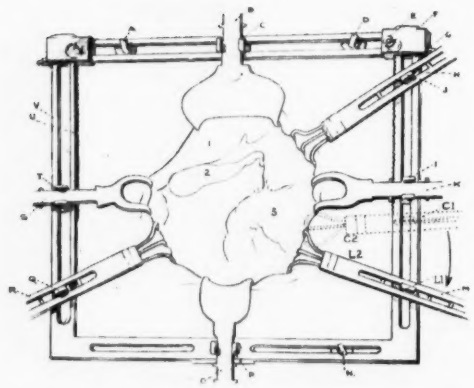

Fig. 5. This is to show how the "mechanical hand" should be inserted and locked. The "hand" is inserted loosely at right angles to bar of frame on to the single hook at *C1*. A lateral movement in the direction of the arrow to *C2* will now jam the hand without letting the intestine out.

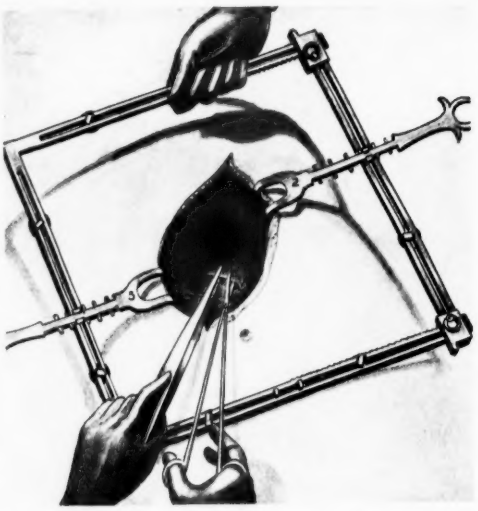

Fig. 6. This shows how, in operations in secondary abdominal cases, a clear space on each side of the incision is made and how into this clear space two retractors are inserted so that the abdominal wall may be lifted to facilitate the disconnection of adhesion from the anterior abdominal wall.

difficulty in gastric operations: it is the most inaccessible; it is important from the point of view of lymphatic infection in carcinoma; it is the starting point for the mobilization of the lesser curvature in contracted and cartilaginous old ulcer. Consequently, we think the main object of any exposure must be this point.

When a left paramedian Bevan's incision has been made,

1. The retractor should be locked in the way described (Fig. 8).

2. The stomach should be deflated by means of a trocar connected to a suction pump (Fig. 7). In the Australasian Medical Congress of 1920, we first drew attention to the great value of this maneuver in difficult operations on gastric conditions.

3. The left lobe of the liver should be covered with some layers of "veil" which should be hooked over to the right with a "mechanical hand" (Fig. 8, *10*). This exposes the upper part of the lesser curvature.

4. The patient is put in the reverse Trendelenburg position, so as to throw light into the depths of the wound.

The importance of adequate exposure of this particular region is also stressed, because we think that an operation on a carcinoma of the pyloric end of the stomach should not be started in the usual way, that is, at the pylorus. In our opinion the stomach should be cut across between Payr clamps proximal to the lesion, and the distal segment should be allowed to hang over to the right so that very accurate dissection of the subpyloric glands and of the adjacent pancreas may be carried out. Bruising of these glands is liable to occur when the dissection is started from the pyloric end.

Very great expertness and speed in bowel suturing can be attained if the frame is used to suspend the bowel segments in proper position by systematic catgut retraction. Advantage should be taken of this in making the gastro-intestinal anastomosis. The segments of stomach and intestine should be fixed together and to the retractor frame by "guy ropes" (Fig. 9, *A* and *B*). This gives a definite tension and a fixed resistance against which suturing may be carried out and this makes for great accuracy and neatness.

Once the retractor is fixed in the wound, very light anæsthesia suffices for an operation on the insensitive stomach.

Posterior wall of the stomach—gastric ulcer penetrating the pancreas. In an operation on the posterior wall of the stomach for a gastric ulcer penetrating the pancreas, the following steps are necessary:

1. The wound is "set" in the way indicated.

2. The stomach is aspirated of air.

3. Large openings are made in the gastrohepatic and gastrocolic omenta.

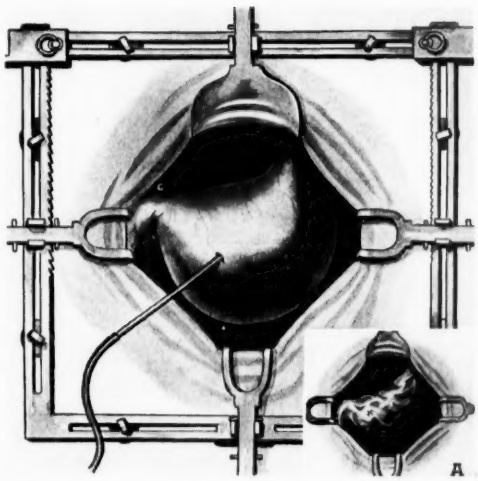

Fig. 7. This shows a stomach which is dilated and filled with air being punctured by a trocar attached to a suction pump. The inset *A* shows the stomach collapsed. In this latter condition it is much easier to operate upon and it allows better operative access to organs in the vicinity.

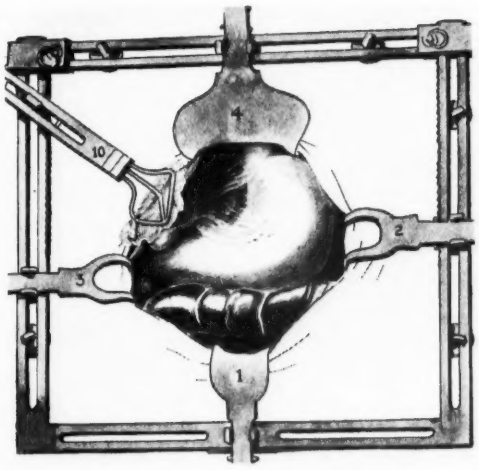

Fig. 8. Exposure of the stomach. Retractor *4* is placed in the upper angle of the wound, and the left lobe of the liver, protected by many layers of gauze, is hooked over out of the way of the lesser curve by "mechanical hand" *10*.

4. With a "mechanical hand" and scarf the transverse colon is held out of the way.

5. The ulcer is exposed and with an aspirating tube a line of cleavage which will be found between the edge of the ulcer and the pancreas is boldly penetrated. The stomach is dried and with the gloved finger the ulcer is shelled off the pancreas. A scarf is drawn through the openings in the gastrohepatic and gastrocolic omenta and drawing on it the posterior wall of the stomach is rotated so that it assumes an anterior position. It is now possible to suture the ulcer in comfort and with precision.

Pancreas. In the ordinary way the exposure of the pancreatic region is most difficult, as the pancreas is so deep down in the abdomen. Manipulations are hampered by the crowding in of the stomach, colon, and the small intestines. With ordinary method it is difficult to light the operation area.

1. The retractor is inserted.

2. A six-inch incision is made in the gastrocolic omentum.

3. A crumpled-up veil is placed over the transverse colon and another over the stomach (which has been previously deflated), and perhaps another over the duodenum. With as many "mechanical hands" as necessary these organs are pushed under the abdominal wall out of the operating area.

4. The area may now be illuminated either by daylight (reverse Trendelenburg position) or by artificial light.

The surgeon will be surprised to find what an enormous difference this exposure makes in operations on the pancreas. Excision of a very large, old, suppurating pancreatic cyst wall in the head of the pancreas and incision of the capsule in acute pancreatitis, have been easily and satisfactorily dealt with by this method.

The kidney from the front. A right upper paramedian incision is made, and the abdominal wound is "set" in the way that has been indicated (Fig. 2). Large folded soft veils are placed over the stomach, ascending colon, and the hepatic flexure. With two "mechanical hands" these structures are drawn toward the midline, and the "hands" are fixed to the median side of the frame. If necessary, a low lying liver may be held out of the way with layers of a scarf and a "mechanical hand" (Fig. 10, 7). The peritoneum is incised lateral to the hepatic flexure and the upper part of the ascending colon. The "mechanical hands" are now unlocked on the medial side of the frame and the colon is stripped from the posterior abdominal wall, the "mechanical hands" reinserted, and this loosened segment of the colon incarcerated still farther into the left part of the abdomen. It may be necessary to use a third small "mechanical hand" on the lower side of the

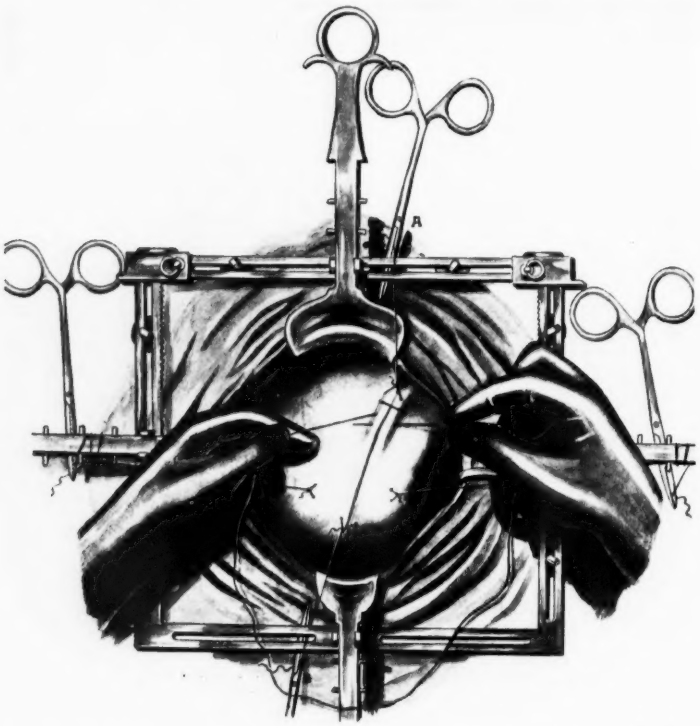

Fig. 9. This gives some idea how segments of stomach and intestine can be fixed to the frame by means of "guy rope" retraction so that exact suturing and accurate adaptation can be obtained and so that suturing can be carried out against constant tension.

frame in order to keep any small intestines out of the operating area. It will now be found that the front of the kidney is well exposed and, if the patient is placed in an exaggerated, reverse Trendelenburg position, the operation area is flooded with light. It is now a very easy matter to isolate the kidney and display its pedicle, which may be delivered more naturally forward than backward. A stab wound in the loin will provide the usual drainage.

This is also the exposure for a chronic subhepatic appendicitis.

Appendiceal region. The average appendicectomy gives no trouble, but a good exposure of the appendiceal region is essential and life-saving in what one might call the "mean appendix," that is, the acutely inflamed appendix that from a developmental error is anomalously situated, as, for instance, in the pelvis or in a retrocæcal position; the appendix which is intensely inflamed and gangrenous and undeliverable; the appendix that is bound down by the fibrosis resulting from inflammation. In all these conditions adequate operative exposure, so as to allow dissection under sight, will avoid intestinal soiling, shock, and bleeding, and make for a neat, expeditious operation.

The following is the method of exposure of a retrocæcally placed acutely inflamed appendix:

The ordinary muscle splitting incision is made, but the incision is continued in the aponeurosis of the internal oblique and transversalis muscles into the sheath of the rectus (after Professor Watson and Davis) (Fig. 11). If the appendix is very inaccessible and more room is required, the incision is connected with a vertical incision *B* in the sheath. The edges of the wound are covered with towelling or rough glove-rubber sheeting (specially made) or with both. With the retractor the abdominal wound is "set," "me-

chanical hands" with small blades being used where necessary (Fig. 4, *D*).

No attempt is made to find the appendix, but by the tracing of the terminal ileum to the cæcum, the ileocæcal junction is located. The base of the appendix nearly always bears a definite relation to this and is isolated and divided by means of a cautery between clamps. The butt is tied and invaginated into the cæcum (Fig. 12, *A*). A crumpled-up veil is placed over the cæcum, which, with the hand, is now pushed well under the abdominal wall and so out of the operation area. It is fixed there with a "mechanical hand" (Fig. 12, *H*). Now by the clamping and snipping of what there is of the appendiceal mesentery, *G*, the appendix itself can gradually be drawn out from under the cæcum without the least tension being put upon it or the slightest force being used. This "lifting" out of the appendix is important, because very often it is the surgeon who, manually enucleating the appendix, ruptures the inflamed, friable appendiceal tip, and distributes infection through the coils of the very susceptible small intestine. When the appendix lies lateral to the cæcum and ascending colon and is very long, extending up toward the liver, it is possible, by means of the lifting action of the retractor, to elevate the abdominal wall away from the intestines and to create a space, previously only potential. Then, when the patient is placed in the reverse Trendelenburg position and the wound becomes sufficiently well lighted, it is possible to dissect out with long instruments one of these long appendices and to clamp its arterial supply.

Acute pelvic appendicitis. In acute pelvic appendicitis the same wound "setting" is used as for the retroperitoneal type of appendix (Fig. 12). The base of the appendix is found in the same way (Fig. 12, *A*). Now with "veils" and "mechanical hands" the cæcum is pushed up into the abdomen and the small intestines are cleared from the appendix as it descends into the pelvis (Fig. 13, *B*). If the patient is now placed in the Trendelenburg position, the appendix can be seen the whole way into the pelvis, so that unhampered by intestines and under good vision, the appendiceal mesentery (Fig. 13, *C*) can be clamped and snipped with long handled instruments and the appendix itself can be lifted out of the pelvis without the slightest injury. In this way the terminal part of an acutely inflamed pelvic appendix, often gangrenous or thin and full of pus, is never ruptured.

It frequently happens that an appendiceal pelvic abscess causes an obstruction of both the small intestine and the sigmoid, "ileus duplicis" (Handley). Here the cæcum and the small intestines adjacent to the appendix will be so much dilated that it would be very difficult to give adequate exposure even to a normally situated appendix and certainly next to impossible to remove the deeply situated, acutely inflamed, abscessed, pelvic appendix. In such circumstances the operation can be made almost easy by the insertion of a hypodermic needle of a slightly larger caliber than usual, connected to an air pump, obliquely through the coats of the cæcum (Fig. 14, *E*) and with this withdrawing intestinal gases. This procedure causes the cæcum and the adjacent foot or so of small intestine to collapse (Fig. 14, *D*). The aspiration through such a fine needle is slow, but the content is mostly gas, and it is remarkable how this maneuver simplifies what appears to be an almost impossible appendicectomy.

Fig. 10. The exposure of a right kidney by the abdominal route. The ascending colon and hepatic flexure, covered with layers of gauze, are held in the abdominal cavity by "mechanical hands" *5* and *6*. The liver, also well protected with many layers of gauze, is held up by the gentle tension of "mechanical hand" *7*.

In difficult appendicectomy in acute cases, we deprecate the use of the paramedian incision and we claim for our technique, that is, the modified "split muscle" incision combined with the use of this special retractor and its "hands," the following advantages:

1. The incision is made directly over the base of the appendix—the best point of attack.

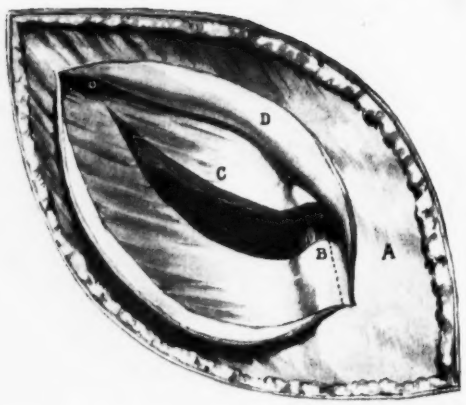

Fig. 11. A modified McBurney incision. *A*, The sheath of rectus; *B*, incision in the conjoined tendon continued into the sheath of the rectus, and, if necessary, vertically down the sheath of the rectus (after Davis and Professor Watson, by courtesy *Journal of the College of Surgeons of Australasia*).

2. The small intestine with its larger and more absorbable lymphatics is not disturbed and soiled, as it must be in the manipulations through, or in suturing of, a midline incision.

3. The pelvis and kidney fossæ—most important regions—are accessible by an aspirating and drainage tube with the least disturbance of small intestines.

4. Valvular drainage may be established and loose suturing may be adopted. This avoids infective necrosis of muscle and subsequent hernia.

The lower end of the ureter. In operations on the lower end of the ureter in the male when the vas deferens must be conserved, a large paramedian incision is not of much advantage. An incision exactly similar to that used for the pelvic appendix may be used, except that it should be made an inch above the inguinal canal. The "mechanical hands" are used in exactly the same way as in the removal of the pelvic appendix, except that they are placed outside the peritoneum and the deep "mechanical hand" (Fig. 4, *A*) is used in the lower angle. This lower angle of the wound should be at a point an inch above the insertion of the rectus muscle into the pubis. At this point the lower end of the ureter is nearest the surface. The "mechanical hands" must therefore be utilized to create the biggest cavity in this region.

The ureter is found at the junction of the internal and the external iliac arteries and traced down to the bladder.

The art of the exposure is the creation of a good operating cavity, adequately lighted (a good Trendelenburg position will probably do this) right over the lower uterer, that is, in the lower angle of the wound.

In a female where the round ligament can be sacrificed without any hurt to the patient, a big paramedian incision will give a more comfortable exposure. In the female in order to create an operating cavity, it will be necessary to push the peritoneum toward the middle line with veils and two "mechanical hands."

The pelvis. This technique is really ideal in operations in the pelvis and makes operations on the rectum and sigmoid very much easier. Retractor *4* fits neatly over the os pubis (Fig. 2).

The wound is "set" in the usual way. The upper end of the retractor frame is lifted; the patient is placed in the Trendelenburg position, when it will be found that the intestines fall easily out of the pelvis into the main abdominal cavity. "Mechanical hands" (Fig. 2) are now used to incarcerate them in this situation. The acute angles of the "mechanical hands" prevent them from encroaching on the operation area. If the rectum or sigmoid is the object of the operation, the latter is left lying in the pelvis If a fibroid is too big to deliver through the retractor, it is delivered first and the retractor is inserted afterward.

Urinary bladder. The ratchet action, "mechanical hands," and four-blade principles of the retractor can be most successfully applied to operations on the urinary bladder, such as those for the prostate, papilloma, or diverticulum.

Prostate. For operations on the prostate the moveable bar *C* is adjusted to a position on the frame about the points *A* and *B*. "Mechanical hands" (Fig. 15) with blades *E* (Fig. 4) are inserted into the opening in the bladder. The bladder wound is now opened with the ratchet which may even tear it a little, until there is a sufficiently large opening through which to work. Into the upper angle of the wound is inserted a "mechanical hand" (Fig. 15, *3*) with a very acute angled blade which is made somewhat like a soup spoon. This is used to push the fundus of the bladder up into the abdomen so as to draw up any retroprostatic pouch and flatten the base of the bladder and also to bring it nearer to the surface. It is our experience that in a fat person the weight of the intestines makes the fundus of the bladder bulge downward and renders a satisfactory exposure of the prostate difficult. It may be necessary to use a small blade (Fig. 4, *D*) in the lower angle of the bladder wound in order to give a bet-

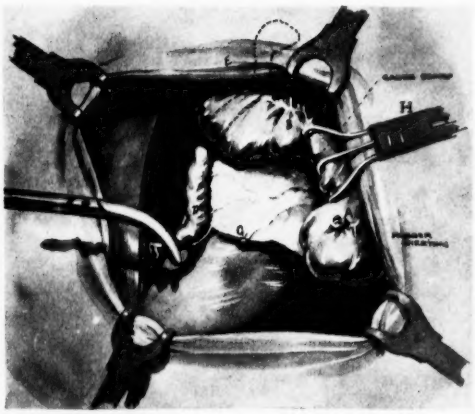

Fig. 12. Exposure for retrocæcal appendix. *A*, base of appendix divided and butt invaginated so that cæcum *B*, covered with a scarf, can be pushed into the abdomen with a "mechanical hand;" *C*, arterial twigs being snipped and tied; *D*, appendix (retrocæcal); and *E*, the abdominal wall is lifted up with the retractor so that the terminal part of the appendix (dotted in) may be removed under good vision. (By courtesy *Journal of the College of Surgeons of Australasia.*)

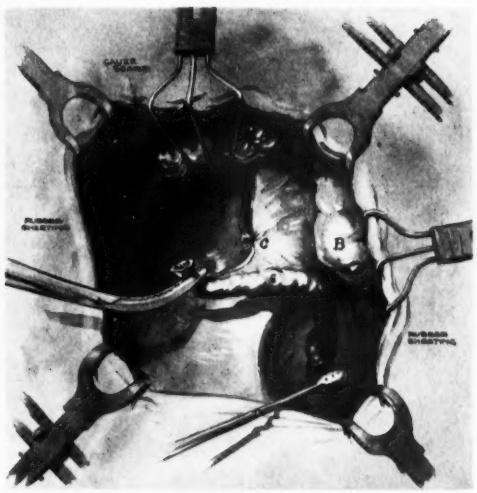

Fig. 13. Exposure for pelvic appendix. Base of appendix divided between clamps and invaginated. *A*, Deflated cæcum covered with gauze and held out of operation area with "mechanical hand" (blade flexed at an acute angle); *B*, small intestines covered first with omentum and then with a scarf and excluded from operation area with "mechanical hand"; *C*, arterial twigs in mesentery clamped, cut, and dried so as to make the appendix come up to the operator; *D*, aspirator for perforating the abscess and rapidly and completely removing the pus; and *E*, pelvic appendix. (By courtesy of *Journal of the College of Surgeons of Australasia.*)

ter view of the anterior margin of the prostatic orifice, and to act as counter-pressure to the "mechanical hand" in the fundus.

A small lamp may be screwed into a socket in the middle of the highly silvered "spoon mechanical hand" (Fig. 15, *3*, inset). From the shelter of the fundus, this lamp reflects light directly on the prostate and trigone or wherever necessary.

The patient should be placed in the Trendelenburg position.

Papilloma. In operations on papilloma of the bladder the exposure will need to be wider and to be contrived so as to suit the situation of the lesion. It may be necessary to insert the blades in a radiate fashion. At any rate they should be so adjusted that the papilloma area is free to be dissected.

Malignant tumor. In malignant tumor of the bladder where it may be necessary to resect a large portion of the bladder wall, a low median incision is made between the recti and pyramidales, and the peritoneum is opened. The retractor is inserted in the usual way and with it the abdominal wall is lifted. The intestines are removed from the pelvis and incarcerated in the main abdominal cavity by means of a veil and two "mechanical hands" (Fig. *2*, *5* and *6*).

The patient is placed in the Trendelenburg position. With a trocar and pump the bladder is aspirated. The bladder is opened and dried out carefully with an aspirator tube. The bladder is isolated and the tumor is resected. As the resection of the tumor proceeds, corresponding or particular parts of the bladder wall should be fixed to the frame by catgut "guy ropes" in order to keep the proper relations for reconstitution of the remnants of the bladder. This allows replanning and easy and exact suture of the much mutilated bladder.

Diverticulum of the bladder. "Guy rope" catgut retraction is particularly valuable in the removal of a very large and adherent diverticulum through the bladder.

The edges of the diverticular opening are freely incised and the neck of the diverticulum separated from the bladder wall. The diverticulum is now freely exposed by the drawing of the bladder wall away from it by a number of "guy-rope" catgut retractions placed symmetrically round the frame. It may even be possible to expose the diverticulum further by the insertion of a couple of narrow deep "mechanical hands." By these means the opening in the base of the bladder is set widely open and brought nearer the surface. This

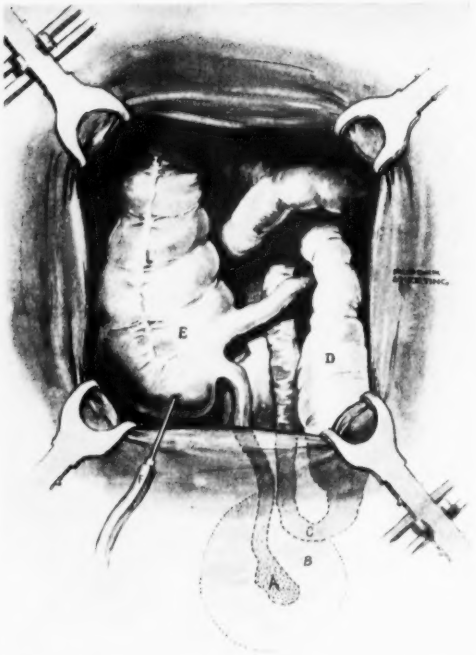

Fig. 14. Exposure of pelvic appendicitis with "ileus duplicis." *A*, Infected appendix (dotted in); *B*, abscess (shadowed in); *C*, paralyzed segment of small intestine; *D*, obstructed small intestine; *E*, dilated cæcum; and *F*, hypodermic needles attached to air pump deflating cæcum.

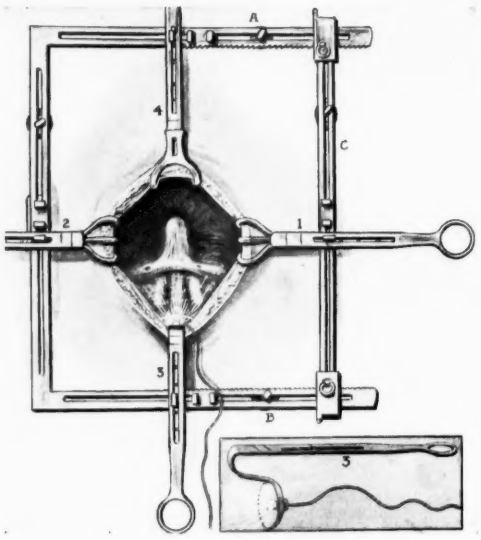

Fig. 15. Retractor set in the bladder for exposure of the prostate. "Mechanical hands" *1* and *2* are used to retract opening in bladder (see Fig. 4, *e*). Retractor *4* is seen in Figure 4, *d*, and retractor *3* is a spoon shaped "mechanical hand" with a light in the middle of the highly silvered spoon.

renders it possible, with long scissors and forceps, to dissect out the diverticulum under good vision, so that it keeps on coming up to the operator, as he snips around the walls.

This system of retraction is also most useful in the extraperitoneal removal of a diverticulum.

SUMMARY

We have found that this technique has great potentiality in enabling the surgeon to get out of serious operative difficulties. To every surgeon there must come a time when, unexpectedly, an almost insurmountable operative problem occurs at an operation or the unexpected happens. For instance, a patient has been operated on for gall stones. No disease of the gall bladder has been found, but examination reveals that the kidney has a dilated pelvis. It is a matter of a few minutes to rearrange the retractors, deliver the kidney into the wound, and explore or deal with the kidney condition without making a fresh incision. Or if a gastric lesion is found, the incision can be made to expose the whole of the stomach by just rearranging the retractor so that the incision is made wider at the expense of its length. The reverse happens. During an operation for a gastric lesion a pathological condition of the gall bladder is found; the gall bladder can be removed without enlarging the incision.

Let us suppose that in operating from the abdomen a hydatid cyst or an abscess of the upper surface of the liver is found; then, it is possible to elevate the costal arch, to press the liver down, and to create a space that enables the surgeon to attack the upper surface of the liver. It is quite unnecessary to go through the pleura. Once the abscess is opened, counter drainage at its lowest point can be easily established. In a similar way, access can be obtained to the left side of the diaphragm, so that adhesions from a spleen can be severed with a scissors, rather than be torn by the hand.

The patient has disease of the gall bladder but needs the removal of the appendix as well. An incision is made as high as possible in the abdomen, just sufficiently big to enable the gall bladder to be removed. The abdominal wall is elevated, a swab on a holder is pushed against the anterior abdominal wall at McBurney's point from inside

the abdomen. A stab incision is made on to this. With the left hand in the abdomen, the appendix is delivered through this stab incision and removed. One stitch closes it. This means that there is an incision very high up in the abdomen and a tiny incision in the lower part of the abdomen—a much better arrangement from the patient's standpoint so far as the strength of his abdominal wall is concerned, than the necessarily big incision in the middle of the rectus, made to give access to a high gall bladder and a low appendix, at a point where there is the greatest postural tone.

An appendix is being removed: it is found that the patient has a uterine fibroid. It is an easy matter by the incision of the sheath of the rectus and the re-arrangement of the retractor to elongate the incision so that the fibroid tumor can be removed without a fresh incision being made. A hernia is found: it is possible to close the opening from the inside. Indeed, additional uses are constantly being found in which this method of operating is a distinct advantage.

This technique has to be seen in order that its potentiality and its rationality may be appreciated, but even we who have employed it for years, could not adequately tell our readers what it has meant to the great number of patients on whom we have operated; to the surgeons whom we have initiated into its many uses; and to the assistants and nursing sisters. Any surgeon who would assimilate this method, must cultivate it before he can regard it as part and parcel of his general technique.

FROM THE DEPARTMENT OF SURGERY OF WASHINGTON UNIVERSITY

ARTHRODESIS OF THE SHOULDER BY MEANS OF OSTEOPERIOSTEAL GRAFTS

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ARTHRODESIS of the shoulder is an operation which is definitely indicated in certain conditions and one which may effect the cure of disease and result in an upper extremity which is very useful as well as free from pain and obvious deformity. However, a firm, bony ankylosis of the shoulder is difficult to obtain, because when the shallow glenoid is denuded the area of raw bone obtained is disproportionately small in comparison to the head of the humerus to which it must be opposed. A further difficulty is that the scapula is movable on the thorax and cannot be completely immobilized by any form of apparatus. Consequently, the usual type of arthrodesis operation often results in a complete failure, or only a fibrous ankylosis of the shoulder is obtained. The difficulty is partly overcome by collapsing the denuded or split acromion on the upper end of the humerus, but even this type of operation is often unsuccessful.

In this paper an operation is described which offers a better chance of success than any other with which I am familiar. It is similar to a procedure which I described in 1926 for the treatment of tuberculosis of the hip.[1] The advantages of the operation are that it gives a complete exposure of the shoulder joint, thus enabling the surgeon to perform a thorough operation, and it supplies extra bone at the points where needed.

INDICATIONS FOR THE OPERATION

The chief indications for arthrodesis are tuberculosis of the shoulder joint, complete and permanent paralysis of the deloid, and certain chronic painful conditions of the shoulder which cannot be relieved by less radical methods. A brief explanation of these indications follows.

Many competent orthopedic surgeons believe that tuberculosis of large joints is most satisfactorily treated by conservative methods, especially heliotherapy. These men will, of course, not consider this or any other extensive operation in tuberculosis of the shoulder. Personally, I have never seen a case of proved tuberculosis of a large joint in an adolescent or adult cured with a useful range of motion in the joint. Consequently, I recommend arthrodesis as soon as the diagnosis is definite and patient is ready for operation.

The paralyses of the deltoid are usually the result of poliomyelitis, and in these cases there is often extensive paralysis of the entire upper extremity. It is almost useless to operate on cases in which immobilization of the shoulder in a good functional position will not materially benefit the patient. For this reason, one should operate only upon the patient who has sufficient muscle power in the arm and the forearm to give him a hand which would be useful if it could be properly controlled. It is also necessary that the patient have sufficient power in the shoulder girdle muscles, especially the trapezius and serratus magnus, to control the movements of the scapula.

The painful arthritic conditions of the shoulder which warrant such a serious procedure as arthrodesis are usually the result of an old fracture involving either the head of the humerus or the glenoid, in which the fragments are healed in malposition, and the mechanics of the joint are disorganized. In these cases the operator can feel that he is not liable to do any harm, as there is rarely enough motion left in the joint to be of use to the patient, but just enough to cause frequent attacks of pain which may or may not radiate down the extremity. Before resorting to arthrodesis in these cases of so-called traumatic arthritis, the surgeon should endeavor to relieve the patient by immobilization in a good functional position and by physiotherapy (local heat and also massage). As a rule, conservative treatment should be continued from 6 months to 1 year before an arthrodesis is performed in a case of traumatic arthritis of the shoulder.

The object of the operation is to fix the humerus to the scapula in such a position that the arm can be elevated to the level of the shoulder or be proximated to the side. This amount of motion is accomplished by the movements of the scapula on the trunk. There is also a certain amount of rotation of the arm and backward and forward motion, which is obtained in the same manner. In the case of infantile paralysis, with total paralysis of the deltoid, the abduction and elevation of

[1] Key, J. A. Treatment of tuberculosis of the hip. J. Missouri State M. Ass., 1926, November, 388-397.

Fig. 1. Split plaster jacket with spica trough for arm, prepared before the operation.

the arm obtained by the patient are practically all due to the operation.

PREPARATION FOR THE OPERATION

If the shoulder is movable and can be abducted to the desired functional position, it is wise to apply, before the operation, a plaster spica jacket which fits well around the iliac crest and includes the shoulder and arm down to the elbow. This will shorten the length of time which the patient must spend under the anæsthetic and the jacket can be applied while he is able to sit or stand. It is applied with the arm abducted 70 to 90 degrees and brought forward about 30 degrees from the frontal plane so that the hand can reach the face. The top of the plaster covering the arm and shoulder is then removed, and the plaster jacket is split on the opposite side and removed. The top is discarded but the plaster jacket with the trough for the arm is saved in order that it may be applied after the operation (Fig. 1). It is useless to include the elbow and forearm in the preliminary plaster because the operation shortens the upper arm slightly and the flexed elbow and forearm will, therefore, not fit in the trough which has been prepared for them.

After the cast is made, the operative fields are given a 48 hour preparation. On the first day the entire arm and shoulder region, including the axilla, is shaved and scrubbed with soap and water, then it is washed with alcohol and ether, and a sterile dressing is applied. As it is convenient to procure the bone grafts from the tibia of the leg on the opposite side, this leg is then prepared in a similar manner. The scrubbing with soap and water, followed by alcohol and ether, and the application of a sterile dressing are repeated on the second day.

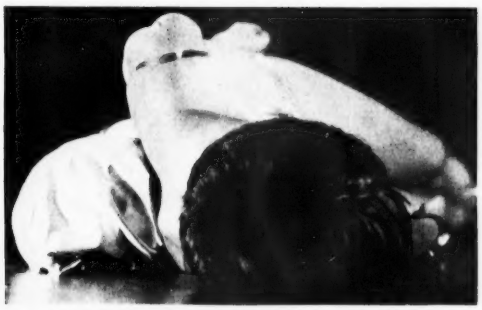

Fig. 2. Position of patient on the table with shoulder elevated. The black line shows the site of the skin incision.

TECHNIQUE OF THE OPERATION

The patient is placed on the table, anæsthetized with ether, and turned on the opposite side with the shoulder facing directly upward; large sand bags are placed next to the back and chest to maintain the position (Fig. 2). The arm is draped in such a manner that it may be moved freely. Sterile stockinette has been found convenient for this purpose. The leg and foot also may be covered with stockinette. Since the operation may be rather long and difficult and since it is always well to be ready to proceed to the conclusion of a major surgical procedure should the patient show symptoms of shock, it is preferable to remove the grafts from the tibia before the operation on the shoulder is started.

A long straight incision is made over the middle of the subcutaneous surface of the tibia extending

Fig. 3. Outline of skin incision. The black dot is placed over the tip of the acromion.

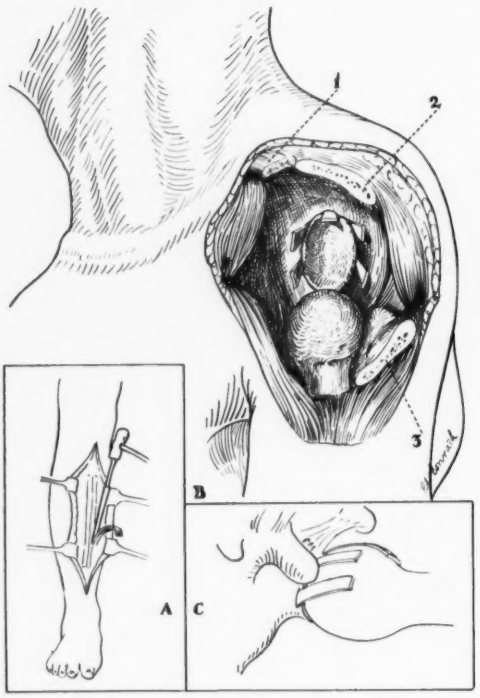

Fig. 4. Exposure by Codman's incision. *A*, Methods of removing grafts from the tibia. *B*, The glenoid prepared for the reception of the head of the humerus: *1*, acromical end of clavicle; *2*, base of acromion cut by saw; and *3*, detached acromion. *C*, Relation of grafts to humerus.

from the level of the tubercle down to the lower fourth of the leg. This is carried down to the periosteum, and the skin and subcutaneous tissue are dissected back on either side. Then, with a knife, four parallel incisions are made in the periosteum. These are about ⅓ inch apart and include practically all of the subcutaneous surface of the bone. Transverse incisions in the periosteum are made at either end of the vertical incisions. With a small curved chisel, the osteoperiosteal grafts are then removed in such a manner that a thin layer of cortical bone is raised with the strip of periosteum. Three such strips are cut and placed in a bowl which is covered and kept sterile. (I do not wrap these grafts in sponges saturated with salt solution, as I believe that this may injure the cells, but simply use a gauze soaked with blood from the wound and, since the bowl is covered, the grafts are thus in a moist chamber.) An assistant closes the wound in the leg, while the operator devotes his attention to the shoulder.

In order that the operation may be performed thoroughly, it is necessary that an adequate exposure of the shoulder joint be obtained. For this purpose I prefer the saber cut, devised by Codman[1] originally for suture of the supraspinatus tendon, but ideal for arthrodesis of the shoulder, as it gives a complete exposure of the joint. The saber cut incision for arthrodesis provides an incision a little more extensive than that described by Codman but the lines and principles are identical.

The skin incision begins in front opposite the lower border of the glenoid and extends straight across the shoulder from before backward directly over the acromioclavicular joint to a similar level behind (Figs. 2 and 3). The incision is carried down to the bone and muscle, and, after the superficial bleeding points have been clamped, skin towels are applied. The anterior and posterior portions of the deltoid are split rather than detached from the clavicle and spine of the scapula. The acromion is separated from the clavicle at the acromioclavicular joint by dividing the capsule of that joint and is then sawed through at its base in the line of the incision, thus detaching the acromion with the flap or epaulet consisting of the lateral portions of the deltoid, together with the skin and subcutaneous tissues. This is retracted outward to expose the subacromial bursa and the superior portion of the capsule of the shoulder joint. The upper portion of the capsule and the loose subacromial tissue are excised in mass, thus exposing the joint. The tendons of the supraspinatus and the infraspinatus are retracted backward, while that of the long head of the biceps is detached from the upper border of the glenoid and sutured to its sheath in the depth of the wound. The synovial lining of the joint is then excised by sharp dissection.

After the synovial membrane and diseased tissues have been removed, the head of the humerus and the glenoid are completely denuded of cartilage and diseased bone, with a curved chisel or gouge, and the periosteum is raised from the upper end of the shaft of the humerus and from the scapula around the margins of the glenoid. If the glenoid is much eroded, the base of the acromion is also denuded and the nerve to the infraspinatus is ruthlessly disregarded as the muscle will be useless anyway if the operation is successful. The same is true of the tendon of the supraspinatus if it interferes with bone-to-bone opposition between the upper end of the humerus and the lower surface of the acromion. As a rule, it is loosened from its insertion and pushed back-

[1] Codman, E. Obscure lesions of the shoulder; rupture of the supraspinatus tendon. Boston M. & S. J., 1927, cxcvi, 381-387.

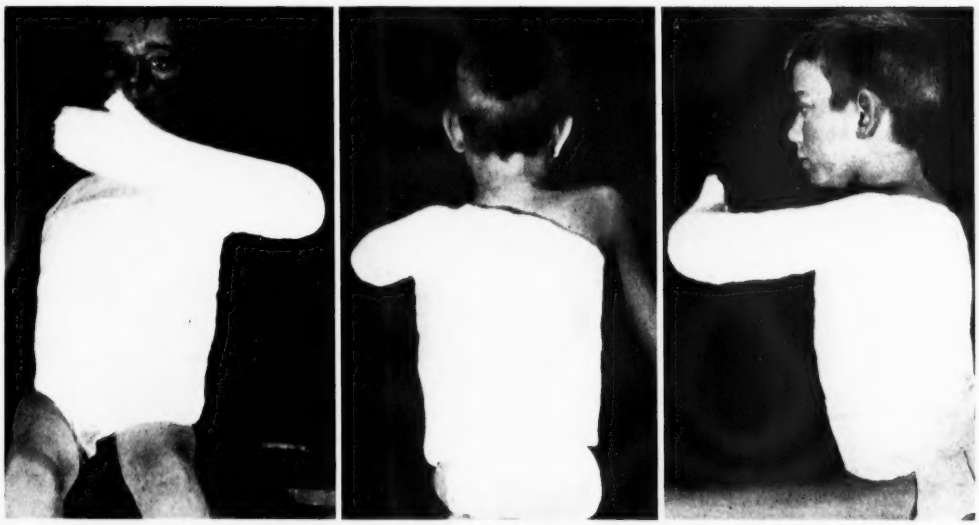

Fig. 5. Postoperative plaster jacket showing position of arm and shoulder.

ward. Hæmostats which were placed on bleeding points during the operation are now removed, and usually it will not be necessary to tie any vessels. The periosteum is now removed from the deep surface of the detached tip of the acromion in order that it may be approximated to the denuded upper surface of the humerus. With a small drill, a hole is made through this fragment and through the base of the acromion at a point opposite for the placing of the suture to hold the fragment in place.

The osteoperiosteal grafts, cut in lengths of about 2 inches, are now inserted as thickly as possible around the borders of the glenoid beneath the elevated periosteum of the scapula with their free ends sticking out like the fingers of a half closed hand to receive the denuded head of the humerus (Fig. 4). The deep or bone surface of the grafts faces inward to make contact with the denuded upper end of the humerus. All of the grafts available are used and several more than are shown in the drawing are placed around the glenoid, spanning the space between its margins and the head of the humerus.

The humerus is then placed against the glenoid and, in tuberculous patients, a small stab incision is made in the skin of the outer surface of the upper arm at a point about 3 inches below the upper end of the humerus. With the humerus held against the denuded glenoid and in the desired functional position, a large nail is introduced through the stab incision and driven through the upper end of the humerus in such a manner that its point enters the glenoid as near its center as possible. The arm meanwhile is held in a position of abduction of about 90 degrees and anterior flexion of about 25 degrees. In non-tuberculous patients the nail will not be necessary, and in tuberculous patients in whom the entire head of the bone is destroyed it will not be practical, as it cannot be driven through thick cortical bone.

It is important from this time on to move the arm as little as possible. The acromion is now sutured to the clavicle by means of chromic catgut, and another piece of chromic catgut is passed through the holes in its tip and in the base of the

Fig. 6. Postoperative arthrodesis of shoulder in a case of infantile paralysis, showing a bony ankylosis of the humerus to both the acromion and the glenoid.

acromion and tied tightly, thus permitting the acromion to collapse upon the denuded lateral surface of the upper end of the humerus. Interrupted subcutaneous sutures of plain catgut are used to close the wound and continuous silk suture to close the skin. No drainage is used. A snugly-fitting dry dressing is applied. One or two 5-yard gauze rolls are used to make a firm figure-of-eight bandage to compress the tissues around the shoulder. This lessens postoperative oozing and hastens healing, in addition to securing more adequate immobilization in the plaster. The split plaster jacket is now slipped upon the patient, care being taken not to disturb the position of the shoulder any more than necessary, and the arm is placed in the plaster trough. The forearm and hand are covered with sheet cotton and plaster bandages are placed around the trough and over the arm and shoulder in order to immobilize the part. The elbow is flexed to 90 degrees, the forearm is supinated, and the plaster is extended to the base of the fingers (Fig. 5). Plaster bandages are placed around the jacket to strengthen it. The head of the nail is left protruding through the skin and through the plaster. If the plaster jacket with the shell for the arm has not been prepared beforehand, it is of course necessary to apply the entire plaster while the patient is under the anæsthetic. If this is to be done on the ordinary Hawley table, the operation should be performed with the patient reversed on the table, that is, with the patient's head at the foot of the table so that when the operation is finished, the sand bags can be removed and the patient turned on his back with the pelvic rest between the shoulders. It is, of course, necessary for someone to support his head when the table is lowered and jacket is being applied.

The position of optimum function for ankylosis of the shoulder is usually given as 75 degrees of abduction for children and 50 degrees for adults with the arm slightly forward from the frontal plane. I use the 90-degree abduction for the first plaster because it enables one to push the humerus firmly against the glenoid while the plaster is being applied and because some abduction is always lost during the period of consolidation.

AFTER-TREATMENT

The patient may be permitted to sit up in bed on the day after the operation and may be ambulant as soon as his strength permits. At the end of 12 or 14 days the plaster jacket is removed and the wound is dressed. The stitches are removed and a new plaster jacket is applied. The nail is removed about a week later and the second plaster is left on about 3 months. At the end of this time it is removed and an X-ray picture is taken. If there seems to be firm body union (Fig. 6), an abduction splint or removable plaster is fitted and the patient is permitted to exercise the arm. In the case of a tuberculous joint, it is better to continue the solid plaster for at least 6 months after the operation before attempting motion. The movable support should be worn for at least 3 months after removal of the plaster.

HEMINEPHRECTOMY OR RESECTION OF A PART OF THE KIDNEY

Report of Four Cases[1]

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IDEAL cases for heminephrectomy would seem to be those in which there is complete duplication of the renal pelvis and ureter, and in which it is necessary to remove only the portion of the kidney involved by the lesion. Large solitary cysts of the kidney form a second group of cases in which the portion of the kidney containing the cyst should be resected whenever possible, instead of the entire kidney being removed. McKim and Smith reported, from the literature, 34 resections of the kidney for solitary cyst, with recovery in 31 cases. This should indicate without further emphasis the value of conservative operation whenever possible in such cases.

I shall report 3 cases in which successful resection of the diseased portion of a duplicated kidney was carried out, and also 1 resection of the lower pole of a kidney containing a large solitary cyst. The technique used in the resections will be described. Success depends on the avoidance of opening into the adjacent calyx of the remaining portion of the kidney, and on the assurance of complete hæmostasis at the site of the resection. To avoid the former, I have found it an advantage, after beginning the resection, to place a finger in the dilated calyx and pelvis of the portion to be resected, so as to assist in determining its outer limits. It has not seemed necessary during the resection even temporarily to interfere with the blood supply to the remaining portion of the kidney. Immediate bleeding from the cut renal parenchyma ceases quickly with the placing and tying of mattress sutures over small bits of muscle tissue, and approximation of the cut edges of the kidney. One may be assisted in this maneuver by making a V-shaped resection if possible. Pieces of muscle are used to prevent the mattress suture from tearing through the parenchyma; it is surprising how much pressure can be used in bringing the edges of the kidney together (Fig. 1, *c*). In 3 of the cases such excellent approximation was obtained that after the mattress sutures were placed I was able to approximate the edges of the fibrous capsule with a running suture (Fig 1, *d*). In one instance in which this was not possible the denuded area of the kidney was covered with a portion of the perirenal fat in the form of a patch (Fig. 1, *c*).

Studies were made pre-operatively and post-operatively of the function of each kidney separately and pyelograms were made of the duplicated kidney. Since details of such procedures have been reported elsewhere, I shall merely say that resection of the diseased portion of the kidney did not interfere with the function of the remaining portion and that resection has been followed in each instance by excellent results (Fig. 2, Case 2).

Case 1. A woman, aged 38 years, had had attacks of pain in the right side of the abdomen, with chills and fever and pyuria since August, 1928. When she was examined November 19, 1928, marked secondary anæmia was found, and the urine contained pus, graded 3. Cystoscopic and pyelographic examination, on November, 22, revealed complete duplication of the left renal pelvis and ureter. Dilatation of the lower pelvis was graded 3; it contained infected urine, graded 4. The upper pelvis apparently was normal; the return of indigocarmine was graded 3. There was no return from the lower pelvis. Excretion of indigocarmine from the right kidney was graded 4.

On December 28, 1928, the lower infected hydronephrotic segment of the left kidney and its pelvis were removed. Nephropexy of the remaining segment was done. The postoperative course was uneventful. Cystoscopic examination, January 15, 1929, showed a return of indigocarmine from the right kidney, graded 4, and from the remaining portion of the left kidney, graded 3. A pyelogram of the remaining segment of the left kidney was similar to that before operation; it was not grossly abnormal. At examination on May 3, the patient was found to be in excellent condition; she was gaining in weight and felt well. Urine from the bladder contained pus, graded 1. On July 22, 1929, the hæmoglobin had increased from 60 to 75 per cent (Dare) and the erythrocytes had risen to 4,150,000. She had been free of pain, had gained in weight, and was in excellent condition.

Case 2. A man, aged 43 years, complained of periodic dysuria with gross pyuria and hæmaturia that had been present since childhood. The urine contained pus, graded 4, and the phenolsulphonephthalein return was 70 per cent in 2 hours. The blood urea was estimated as 30 milligrams for each 100 cubic centimeters. Cystoscopic and pyelographic examination on January 2, 1929, revealed complete duplication of the right renal pelvis and ureter. The lower pelvis and its calyces were dilated, graded 3; the upper pelvis was normal (Fig. 1, *a*). Urine from the upper pelvis contained pus, graded 1; from the lower pelvis it was graded 3. The left kidney contained pus, graded 2.

The lower pelvis of the duplicated right kidney was resected on January 22. The pelvis was saccular and when not distended, measured 5 centimeters in diameter (Fig. 1, *b*). Its ureter was three times normal size. Ureteropelvic obstruction was not demonstrable. Postoperative course was uneventful. On February 12, urine from remaining portion of right kidney contained pus, graded 1, incision had healed, and patient's condition was excellent.

[1]Submitted for publication August 21, 1929.

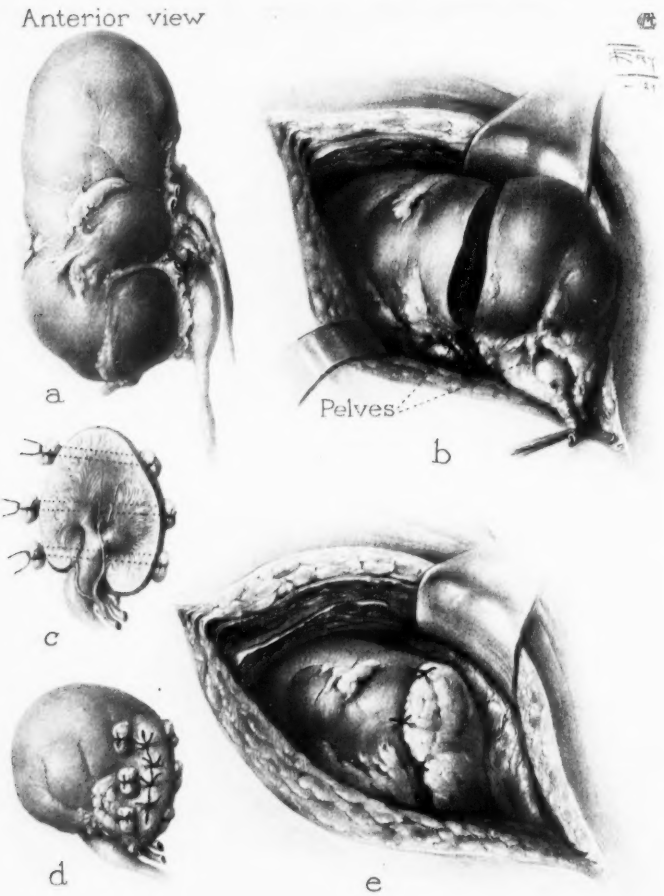

Fig. 1. *a* and *b*, Heminephrectomy or resection of the lower infected hydronephrotic portion of the right kidney; *c*, approximation of cut edge of remaining kidney by mattress sutures tied over bundles of muscle; *d*, closure of renal capsule by suture; and *e*, the use of a patch of perirenal fat when the cut end of kidney can be closed, as in *d*.

CASE 3. A woman, aged 29 years, had complained of abdominal distress for a number of years. Pyuria had been discovered on examination. Cystoscopic and pyelographic examination on April 15, 1929, revealed complete duplication of the right renal pelvis and ureter; the lower of the two portions appeared normal. Dilatation of the upper portion was graded 2 and the calyces were obliterated. Dilatation of the corresponding ureter was graded 2 to 4 throughout its course. Moderate infection was present. Indigocarmine was not excreted from the upper pelvis of the right kidney, but from the lower pelvis excretion was graded 4. Excretion from the left kidney was also graded 4.

On April 25, the atrophic, infected, upper portion of the right kidney, and part of the ureter were removed (Fig. 3). An anomalous renal artery and vein crossed both ureters. They were not divided because they appeared to constitute the entire blood supply of the lower portion of the kidney, which seemed normal, and was preserved (Fig. 4). Postoperative convalescence was normal. Cystoscopic and pyelographic examination, about 6 weeks later, showed the outline of the remaining segment of the right kidney to be the same as before operation, with slight clubbing of the calyces. The function of the remaining segment of the right kidney was reported to be normal; excretion of indigocarmine was graded 4. Urinary infection was not present.

CASE 4. This case is included in the series since the type of resection performed was similar to that used in

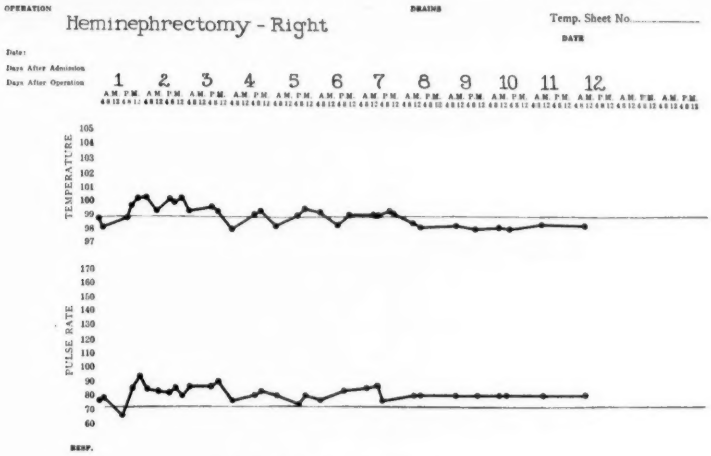

Fig. 2. Case 2. Temperature chart.

heminephrectomy and because pre-operative (Fig. 5) and postoperative (Fig. 6) pyelograms, with a lapse of 8 months between, have been made.

In October, 1926, a woman, aged 50 years, noticed a lump in the left side of the abdomen, which was more painful when she moved. The mass had increased in size steadily. In April, 1928, the feet and ankles had begun to swell. In the last 3 or 4 months before examination at the clinic the abdomen had increased in size and she had been told by her physician that this was due to ascites.

In the left side of the abdomen a mass was palpated which extended for 5 centimeters below the level of the umbilicus; it was freely movable and approximately 10 centimeters in diameter. The urine contained pus, graded 1. The blood count was normal. The Wassermann reaction of the blood

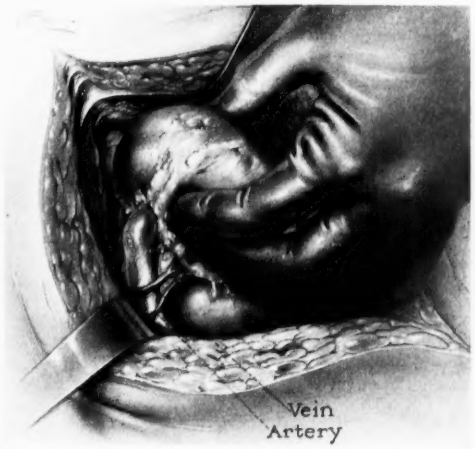

Fig. 3. Case 3. Removal of the upper, infected, hydronephrotic portion of the duplicated kidney on the right side.

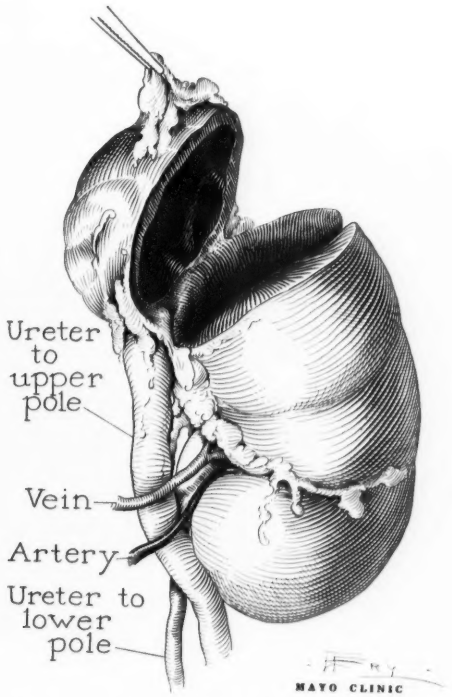

Fig. 4. Case 3. Anomalous artery and vein, the only blood supply to the normal lower segment of the duplicated right kidney.

Fig. 5. Case 4. Pyelogram before resection of a large solitary cyst in the lower pole of the left kidney.

Fig. 6. Pyelogram 8 months after resection of the cyst and the lower pole of the kidney.

was negative. Roentgenograms of the kidneys, ureters, and bladder showed a circumscribed shadow in the region of the lower pole of the left kidney opposite the second and third lumbar vertebræ. Cystoscopic examination was performed on October 12. The pyelogram of the left kidney was normal save for the lower calyx, which was elongated and flattened on a spherical shadow of the mass. The function of both kidneys was normal. The left kidney was not infected.

Fig. 7. Kidney removed on eighth day because of hematuria. Resection of the lower pole had been done and a solitary cyst removed. Attention is called to the healed cortex of the lower pole of the kidney at the site of the resection, and the sclerotic open mouthed blood vessels in the calyces.

On October 16, operation was performed through a left lumbar incision, with resection of the lower pole of the left kidney and removal of a solitary serous cyst, which was distended to 15 centimeters in diameter and contained approximately 300 cubic centimeters of straw colored fluid. The remainder of the kidney was normal in size and consistency. It seemed advisable to remove only the lower portion containing the cyst, which was done, with reconstruction of the lower pole by mattress sutures tied over small bundles of muscle. The cut edges were brought together completely and the capsule was sutured. The postoperative convalescence was uneventful. The patient was dismissed from the hospital October 29, 13 days after operation.

On June, 6, 1929, the patient returned for examination. The urine was normal. Roentgenograms of the kidneys, ureters, and bladder were negative. Cystoscopic examination showed a bifid type of pelvis with ptosis graded 1; the pelvis was otherwise normal. The ureter was normal. The patient's general condition was excellent.

Since this article was handed in for publication two additional resections of the kidney have been performed in one case of hydronephrosis of the lower segment of a duplicated kidney and in one of solitary cyst of the kidney.

The patient with hydronephrosis was a woman aged 39 years. The infected hydronephrotic segment (lower) of the left kidney was removed.

In the second case the patient was a woman aged 64 years. A large solitary cyst of the lower pole of the left kidney was resected. Eight days afterward nephrectomy was performed because of continuous hæmaturia. Examination of the removed kidney showed that the bleeding was due to sclerotic open mouthed branches of the renal artery (Fig. 7). The patient recovered, but the corollary seems to be that plastic procedures on the kidneys of elderly patients with arteriosclerosis may be a radical rather than a conservative procedure.

Successful heminephrectomy or resection of a part of a kidney has been reported by Albarran, W. J. Mayo, Young and Davis, and Rumple. Albarran's patient was operated on in 1905. Gayet, in 1912, reported heminephrectomy in a case of duplicated kidney from which the patient recovered in 3 months. At that time, 17 cases had been reported in the literature. According to Young and Davis, the 3 resections of the kidney, performed by W. J. Mayo and reported by Braasch in 1912, were probably the first successful operations of the kind reported in this country. Young and Davis reported successful heminephrectomy (removal of the portion of a duplicated kidney containing a calculus) in 1917. At that time, they were able to find only 26 cases in the literature in which operation had been done for complete duplication of the renal pelvis and for different grades of ureteral duplication. In 20 of these, nephrectomy had been performed. They stated that in 16 of these double kidneys, half of the kidney was normal and that partial nephrectomy could have been performed. They gave a detailed description of the embryological development of this abnormality.

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USE OF ULTRAVIOLET LIGHT IN THE PREPARATION OF INFECTED GRANULATION TISSUE FOR SKIN GRAFTING; THE VALUE OF VERY THICK THIERSCH GRAFTS

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THE grafting of skin on infected granulation tissue has always been attended by a great number of failures. When the areas involved are large, it has often required many months to cover them. Following repeated failures, the persistent infection, and increasing cicatrization of the wound render the surface progressively less favorable for the growth of epithelium. We believe that the method of skin grafting we are about to describe is a distinct improvement over those commonly in use. In our hands, it has been almost uniformly successful and has brought about a great improvement in our results.

Granulating surfaces resulting from third degree burns or injuries which destroy large areas of skin are always infected. If healing has been delayed by the great size of the wound or by excessive sloughing, the granulations are œdematous and poorly supplied with blood. In cases of very long standing, the wound presents the appearance of a callous ulcer with a thick base of poorly vascularized scar tissue underlying cyanotic indolent granulations over which epithelium grows poorly or not at all. It is evident that under these conditions, skin grafts will not grow. The blood supply must be revived and the infection must be overcome.

PREPARATION OF GRANULATION TISSUE

The steps in preparation of the surface to be grafted will vary according to existing conditions. If the patient is anæmic or debilitated, blood transfusion may be necessary to raise his general resistance. For an infected or sloughing wound, we first employ intermittent soaking in normal or hypertonic salt solution with continuous wet dressings of ½ per cent chlorazene solution. The dressings are changed daily. If during the stage of sloughing, the granulations become œdematous and indolent, they may be scraped away and given a fresh start. Often, however, we have found that such granulations may be rendered firm and vascular by means of a pressure dressing of dry gauze compressed against the wound with elastic bandage or adhesive tape.

When the wound is of too long standing, with a resulting thick fibrous base, it is necessary to excise this tissue completely and allow a thin layer of granulations to develop on healthy tissue. The same procedures are essential in the correction of extensive scar contractures where wide excisions are necessary to relieve deformity.

When in any case these measures have insured an adequate blood supply to the granulations, the problem of infection is still to be dealt with. In the presence of purulent exudates, the grafts are floated loose and destroyed by proteolytic ferments. Even with lesser degrees of infection, such that the granulations are covered by a thin whitish scum of coagulum, grafting is liable to fail. The tissue must be firm, beefy red, and clean.

THE USE OF ULTRAVIOLET LIGHT

It occurred to us 3 years ago that superficial infection in granulation tissue might be effectively reduced by exposure to ultraviolet light. This idea was suggested by the use of ultraviolet light to sterilize water. Our observations lead us to believe that granulation tissue should not be subjected to heavy exposure. Accurate judgment as to the duration and number of treatments is acquired only by experience. Each case is an individual problem, and treatment will vary accordingly. We have used air-cooled lamps of standard make, average voltage 70 at close range (10 inch distance). The time of any one exposure may be as great as 5 minutes where the granulations are in a bad state. Treatments are given daily and the time is reduced to 1 or 2 minutes as the surface improves. It may also be desirable to secure a milder action by removing the lamp to a greater distance. The normal reaction is one which renders the granulations red, vascular, and surprisingly free from exudates.

ADVANTAGES OF THE THIERSCH GRAFT

When by the procedures just described, a thin but firm bed of beefy red, non-infected granulation tissue has been built up and when a thin blue line of growing epithelium can be seen at the edges of the raw area, conditions are right for skin grafting. The question of what type of graft to employ must now be considered. The ordinary

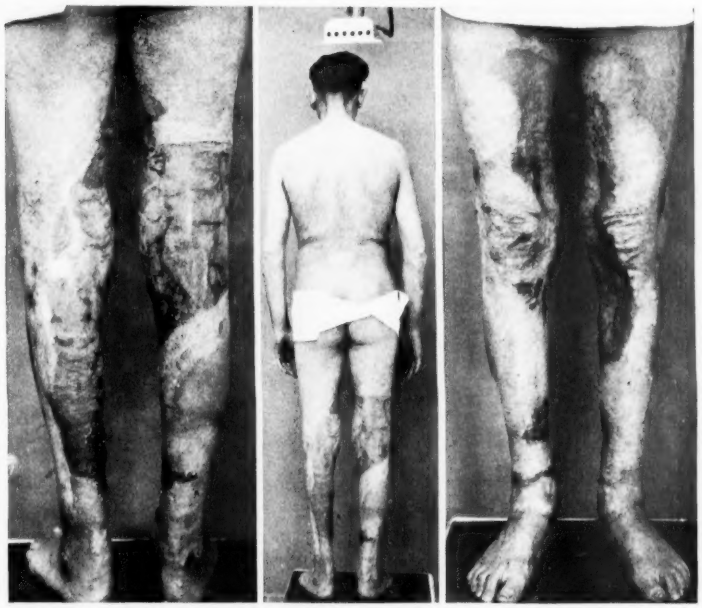

Fig. 1. Case 1. Three views showing result 6 months after Thiersch grafting extensive third degree burns of the legs.

Thiersch graft has been favored by most authors for the covering of areas on the body which will not be subjected to trauma. The whole thickness graft or the pedicle graft has always been favored for regions in which a good cosmetic effect is desirable or in which the graft will have to withstand constant trauma.

Our experience has shown us that a very thick Thiersch graft placed on granulations prepared as advised will give under any conditions as good cosmetic and functional results as a whole thickness free transplant. The thick Thiersch graft obviously cannot entirely replace pedicle grafts in cases in which it is necessary to transplant whole skin with subcutaneous fat. The indications for, and the limitations of, this type of plastic surgery are not included in the scope of this paper. Whole skin free transplant grafts, however, especially if the size is large, seem to us to be biologically unsound. They are very disfiguring to the area from which the skin is cut and are, furthermore, prone to fail because of poor viability.

For these reasons the Thiersch graft is by far the more useful type of free skin transplant. Thiersch grafting both takes and leaves epithelium. The ordinary Thiersch graft should be cut so that the papillary layer of the skin is bisected. The cut surface heals spontaneously by generating epithelium which appears only slightly different from normal. By this technique large areas of

Fig. 2. Case 2. Two views of chronic popliteal ulcer healed by thick Thiersch graft. Appearance 9 days following graft and result at end of 2 months.

Fig. 3. Case 3. Two views taken before grafting. Leg deformity as shown. Web contracture of knee. Muscle contracture at hip due to bad position. View at right shows appearance 3 weeks following excision of scar and division of hamstring tendons.

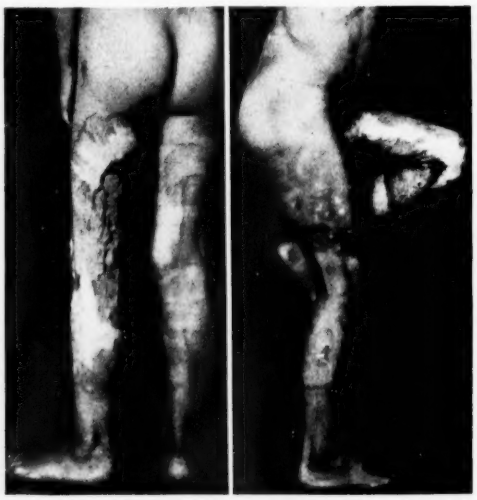

Fig. 4. Case 3. Two views showing result 6 months after Thiersch graft. Deformity corrected. The scar is covered with pliable skin, and there is complete restoration of function. Leg can be fully flexed and extended.

growing epithelium are placed in close contact with a rich capillary bed of healthy granulation tissue. Since epithelium is a tissue which normally grows upon granulations and normally is nourished by osmosis, permanent viability should be possible. It occurs to us that in the free transplanting of whole skin this principle is lost. When the deeper non-epithelial layers of the skin are included in the graft, a much more complex process of nutrition is required. More or less necrosis is to be expected. The end-result may be total sloughing or, with better success, a graft largely replaced by scar tissue and covered with an epithelium not as good as that obtained in a successful Thiersch graft.

The very heavy Thiersch grafts to which we have referred are cut about twice as thick as the ordinary Thiersch graft. They are of leathery texture, and comparable in thickness to the deep small grafts of Davis, but may be cut to large size, as recently described by Blair and Brown. The area from which they are taken regenerates epithelium from the lowermost points of the papillæ, from sweat glands, and from hair follicles. The resulting scar is slightly less satisfactory than that of an ordinary Thiersch cutting. We employ these thick grafts to cover flexor surfaces, especially the popliteal space, and other areas where trauma must be expected. A successful graft of this type results in a surprisingly good quality of skin.

DRESSINGS

Dressings of every description have been advised for skin grafts. Since the chief factor in any case is the preparation of the surface to be grafted, it is not surprising that fair success has been reported with the use of various dressings. For 2 years we have been obtaining uniformly good results with 90 to 100 per cent "take" in the grafts by means of a pressure dressing, the essential details of which were devised by Dr. W. D. Little of this clinic.

A single layer of sterile gauze moistened with salt solution is laid directly on the grafted surface in good contact with the grafts and the small areas of granulation tissue which may remain uncovered between them. On top of this are placed numerous layers of loose dry gauze, sufficient to absorb any exudates which work out around the grafts. With this dressing secured, the pressure dressing is applied by means of large bunches of ordinary hospital wool, held firmly under a final wrapping of all cotton elastic bandage. The entire dressing is left undisturbed for 5 to 7 days.

We believe this dressing to be correct in principle. The pressure holds the grafts in firm contact throughout the period required for union,

and effectively discourages the exudates which otherwise tend to lift the grafts. Exudates which escape around them are absorbed into the superimposed layers of gauze. Because of this advantage, we do not favor the use of sheet rubber, oiled silk, or any other non-absorbent material as an initial dressing. There need be no fear that the gauze will stick and pull loose the grafts. At the end of 5 to 7 days, when the dressing is changed, all viable grafts have grown firmly in place. The outer dressings are removed and the gauze soaked loose with physiological salt solution.

Subsequently we employ ordinary dressings wet with salt solution and changed daily, until the wound is again clean and growing epithelium is seen. A thin outer layer of the graft will peel off in the same manner that cornified epithelium normally sheds itself. All the growing layers remain intact and proliferation from the edges is prompt. At this stage vaseline gauze may be employed as the dressing until healing is complete. Vaseline gauze also makes an excellent dressing for the surface from which grafts have been cut. Grease dressings are never advisable on granulations which are being prepared for grafting. In general the treatment best suited for the preparation of granulation tissue is more or less discouraging to the growth of new epithelium. For this reason, an entire area should be prepared carefully to insure success. If there is doubt, and the surface is great, test grafting of a small part is advisable. Otherwise the entire area should be grafted at one operation.

When the skin grafts have been placed upon areas of the body not suited to pressure dressings, we employ with good success an open method of treatment, protecting the grafts by a cage of screen wire for 3 or 4 days until they adhere firmly. Whenever possible, we prefer the pressure dressing for reasons already given. It is especially applicable for extremities. It should be noted further that, whenever the grafted wound involves the flexure surface of a joint, full extension should be maintained until healing is complete. If there is any tendency to contracture, the splint should be continued until all tendency to cicatrization has ceased. Children are especially prone to contracture. Splints are indispensable. If contracture is permitted, deformity is inevitable.

RESULTS

A successful Thiersch graft, such as we have uniformly obtained by this technique, results in an epithelial covering far superior to the cicatrix which must result from prolonged granulation. This grafted skin acquires a soft velvet-like contour and a flexibility which closely approximates the normal. Hairs are absent and there may be a slight increase in pigmentation. As time elapses, the disfigurement becomes progressively less noticeable. Especially is this true of children in whom repair processes are most active. We have carried out these procedures in a large series of cases with most gratifying results. Approximately 100 patients have had skin grafting operations after radical mastectomy without a failure. In a number of extensive third degree burns we have produced healing with a minimal amount of scar and a minimum loss of time, the interval ordinarily not exceeding 2 months. Some of the possibilities of this technique are exemplified in the three cases reported herewith.

Case 1 is a man who was saved from death or permanent disability by massive skin grafting operations. The chief problem was to combat infection and prepare large granulating surfaces for grafting. Massive failure would have meant a loss impossible to restore. Homografting, that is, from one individual to another has never been successful to our knowledge. It is not within the scope of this paper to enter further into this subject except to regard homografting as a biological problem as yet unsolved. With a successful technique of Thiersch grafting, the necessity of securing a skin donor should be rare indeed.

Case 2 is a man disabled for 4 years because of unsuccessful skin grafting. Following the proper removal of the accumulated scar tissue, a well managed Thiersch graft gave a splendid result where a pedicled graft and whole skin transplants had failed.

Case 3 shows the extent of deformity which may arise from a burn scar contracture, emphasizes the urgency of maintaining extension, and demonstrates further the indications for Thiersch grafting.

Case 1. No. 25245, Orville C., aged 33 years, was admitted to the Robert W. Long Hospital, October 20, 1927, in a state of extreme emaciation with extensive third degree burns of 4 months' duration. As the result of an explosion in a paint and lacquer shop, both his legs had been burned from trochanters to ankles. The areas of first and second degree burn had healed. There remained large areas of third degree burn involving more than half of each leg on inner and posterior surfaces. In these regions there was unhealthy granulation tissue covered with purulent exudate.

He was emaciated and prostrated with septic temperature and rapid pulse from prolonged infection. The granulations were given daily exposure to ultraviolet light and frequent dressings with 1 per cent chlorazene solution. Due to these measures and a blood transfusion, his condition rapidly improved. By the technique we have described the granulations were covered with Thiersch grafts of good

thickness. The grafting was done in two operations, the left leg on November 24, 1927, and the right 9 days later.

Grafts were cut from abdomen, thorax, and back. For the entire surface, the grafts showed fully 90 per cent "take" and there was practically complete epithelization on December 23, when the patient was allowed to go home for Christmas vacation.

Since the legs had been maintained in complete extension, there was never any tendency to contracture. For several months there was cyanosis and circulatory stasis, during which time the patient walked with crutches. With the aid of massage and passive motions, the difficulty was relieved and perfect function was restored at the end of 6 months. At the present time, function in the extremities is normal, health is excellent, and the entire surface is covered with skin of good quality (Figs. 1, 2, and 3).

CASE 2. No. 28281, Mitchell, P., aged 35 years, was admitted to the Robert W. Long Hospital, March 29, 1929, with a callous ulcer of 4 years' duration on the right popliteal space. His injury in 1925 was a gasoline burn involving the posterior aspect of the right leg. After 22 months in another hospital and repeated attempts at skin grafting, he was released with an unhealed area in the popliteal space. There were three unsuccessful attempts to heal this ulcer with whole skin grafts, the last failure occurring at one of the best surgical clinics in the country. The patient was referred to us with the advice that some type of pedicled graft would be necessary. On previous occasions, however, a pedicled graft taken from the only accessible area of the other leg had failed.

Examination revealed a callous ulcer 3 inches in diameter in the right popliteal space. The ulcer was cyanotic; the epithelial covering over the posterior aspect of the leg was of poor quality; and there were marked œdema, cyanosis, and induration. On April 1, the ulcer and the surrounding cicatrix were given extensive débridement, removing dense scar tissue 2 centimeters deep, so that the normal structures of the popliteal space bulged into the wound. The edges were beveled toward the periphery, the final wound being about twice the size of the original ulcer. This was dressed for 10 days with chlorazene packs, and given 4 exposures to ultraviolet light in the last 4 days of that time. On April 11, 1929, there was a bed of excellent granulations upon which we placed five large thick Thiersch grafts. When the pressure dressing was removed at the end of 7 days, the grafts had "taken" 100 per cent, leaving only three narrow zones of uncovered granulation tissue. When healing was complete, the leg was given massage and passive motion.

The patient was allowed to walk out of the hospital 1 month after the graft was done.

Observation on June 12, 1929, showed an excellent, pliable growth of skin, no cyanosis, and only transient œdema after 4 hours of walking. Complete restoration of function is to be expected.

CASE 3. No. 5994, Claude R., aged 7 years, was admitted to the James Whitcomb Riley Hospital, September 7, 1928, with a vicious contracture of the left leg from a burn of 6 months' duration. Five days later the popliteal contracture was given complete débridement. Tenotomy of all the hamstring tendons was necessary to obtain extension of the knee. The exposed great vessels and nerves were covered with two flaps of fat and fascia and the wound was allowed to granulate. Dressings and ultraviolet light were employed according to the described technique.

A cast and later a Thomas splint were employed to maintain complete extension. On October 3, 1928, the large area of healthy granulation tissue involving the popliteal space and posterior aspect of the leg was covered with Thiersch grafts of good thickness. Removal of the pressure dressing at the end of 7 days showed 100 per cent "take" in the grafts.

One month later the patient was discharged, walking in a cast to prevent contracture. After 6 weeks, the cast was discontinued. Observation in 6 months showed complete restoration of function. There was slight keloid tendency but the scar was soft, flexible, and covered with skin of good quality.

CONCLUSIONS

1. By the methods we have employed, Thiersch grafts cut to proper thickness and successfully transplanted give a better result than do whole skin grafts.

2. The factors which render granulation tissue unsuited for grafting are cicatrix formation and infection.

3. Exposure to ultraviolet light is a valuable adjunct in the preparation of granulations. The surface must be beefy red, vascular, and free from exudates.

4. Excellent results may be obtained by dressing the grafts under pressure with dry gauze, wool, and elastic bandage.

5. For the grafting of small areas which will be subjected to trauma and for flexor folds about joints, we employ very thick Thiersch grafts. Joints should be splinted in full extension until all tendency to cicatrization has ceased.

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CHRONIC RECURRING TEMPOROMAXILLARY SUBLUXATION

Surgical Consideration of "Snapping Jaw" with Report of a Successful Operative Result[1]

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THE appropriate term of "snapping jaw" has been applied to a certain group of functional derangements of the temporomaxillary joint which exhibits a peculiar susceptibility to minor disturbances of its mechanism. This disturbance of function is usually attributed to an abnormal peri-articular relaxation which permits an undue mobility of the condylar head within its glenoid cavity. The simplest form of the condition is encountered with great frequency and victims of it, although suffering no actual pain or discomfort, are nevertheless subjected to a constant annoyance as a result of the more or less conspicuous snapping noise emitted by the joint as the head of the inferior maxilla glides through its arc in response to such physiological demands as talking, yawning, or the mastication of food.

Confined within these limits and manifested by such unobtrusive clinical symptoms, snapping jaw scarcely assumes the dignity of a surgical problem. Indeed, in discussing surgical diseases of this joint, standard surgical texts limit operative indications to such conditions as ankylosis, arthritis, irreducible dislocations, and a few unusual fractures. Subluxation of the joint as a surgical consideration is either dismissed as of no importance or its existence is completely ignored.

However, ample evidence is at hand to support the contention that this minor derangement of the temporomaxillary joint may give rise to clinical manifestations which demand urgent and radical intervention. An appreciable number of cases is on record, among them the one herein reported in which the commonly observed picture is complicated by attacks of acute, severe joint pain, by "locking" of the joint in various positions, or by actual fixation of the inferior maxilla with the mouth in the wide open position. Relieved for the moment spontaneously or by some manipulation, these attacks invariably display a disposition to recur with increasing frequency and severity, thus becoming not only a constantly menacing source of embarrassment but eventually threatening the integrity of the very highly important function delegated to this joint.

Malgaigne in 1855 collected a series of 76 cases of snapping jaw of which 54 were bilateral and 22 unilateral, the common age incidence falling between 20 and 30 years.

Annondale reported 2 cases in 1887, both occurring in females, aged 38 and 18 years, respectively. In the first instance the patient's jaw became locked during a vomiting attack and thereafter she experienced characteristic manifestations of snapping jaw, frequently complicated by pain and fixation. The second patient found her jaw fixed in the wide open position following the act of yawning. Manual reduction corrected the condition but thereafter the patient complained of a slipping joint. Tartara saw in an infant, aged 15 months, a subluxation sustained during a convulsion and Pughe observed a similar case in a child 2 years old following a blow upon the lower jaw. Pringle suffered from the condition himself and had studied 4 other cases, 2 of which were in medical students. Ashhurst operated upon a girl aged 16 years who for 2 years had complained of a painful unilateral subluxation with locking, which occurred during the act of eating or talking. During the latter portion of this period, it was necessary to keep the lower jaw bandaged owing to the fact that subluxations frequently occurred with the mouth closed. Blake describes a male patient, aged 27 years, in whom the condition became so extreme that subluxation took place during sleep.

These and numerous other similar reports contributed by Perthes, Loessl, Podlaka, Schurtzel, and others indicate not only the frequency of the condition but give as well a conception of some of its clinical manifestations.

With the demonstration of such inherent potentialities, snapping jaw may, on occasion, assume a considerable degree of clinical importance and require the application of some surgical method for its relief. The appropriate measures to be employed, however, are still a matter of conjecture and the limited number of cases reported to date have not conclusively proved the superiority of any particular procedure. In fact, the methods advocated are well-nigh as numerous as the patients operated upon and, in most instances, have been ingeniously developed, without the aid of precedent, to meet the exigencies of the moment.

[1]Case presented before Surgical Section, New York Academy of Medicine, May 7, 1926.

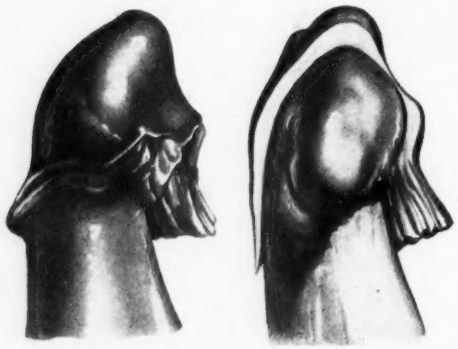

Fig. 1 (left). Lateral view of the condyle of the mandible capped by the articular disc showing sinuous outline of latter and its attachment to the external pterygoid muscle. (After Pringle.)

Fig. 2. Sagittal section of the articular disc, one-half of which has been removed to show the central and anterior ridges with depression between them. The attachment of the external pterygoid muscle also is shown. (After Pringle.)

It is the intent of the present report to add to the existing meager knowledge of the subject merely another experience which may perhaps contribute a better conception of temporomaxillary subluxation and possibly lead to the development of standardized methods for its treatment.

Concerning the nature of this lesion the conclusion naturally first suggests itself that the disturbances observed are dependent solely upon simple, complete, recurring dislocations of the condyle of the inferior maxilla, differing only in degree from the common traumatic dislocations, with which it was therefore classified for a considerable period of time.

In 1822, however, Sir Astley Cooper directed attention for the first time to the possibility that relations intermediary between normal and complete dislocation might exist between the condyle and its glenoid cavity, i. e., incomplete luxation or, as he termed it, subluxation.

According to his conception, subluxation of this particular articulation involved the separation of the interarticular fibrocartilage or meniscus from the condyle to which it is normally firmly attached, followed by the riding forward of the condyle, without its meniscus, onto the articular eminence. In short, the process was essentially an intrinsic internal derangement of the articulation, quite distinct, etiologically and pathologically, from the result of external trauma as seen in the simple complete dislocations. As a result of Cooper's experience with 4 cases, he came to the conclusion that the disease was practically confined to the female sex in which general depletion and lowered resistance, by determining an abnormal relaxation of the joint ligaments, became the actual inciting factors in this type of interarticular disorganization.

Even though the results of subsequent investigation seem to call into question this interpretation of the mechanism productive of snapping jaw, Cooper's observation derives its real importance from the fact that it established the identity of subluxation of the temporomaxillary joint in particular and directed attention to the significance of internal joint derangements in general.

This variety of dysfunction is, of course, not confined to the temporomaxillary joint, for its prototype is not uncommonly observed in such joints as the shoulder, hip, and knee—in other words, in those articulations the functional demands of which have developed the need for specialization in structure.

It is pertinent at this point to recall certain biological principles which have a practical bearing upon this subject. In general, it may be stated that the survival of a species is dependent upon the integrity and efficiency of certain physiological processes which are vital to the individual of the species. Nature's methods of safeguarding and rendering more effective such vital functions are well demonstrated in race history as developmental specialization. Specialized functions require specialization in structure proportionate to the importance of the function concerned.

As applied particularly to articulations, we find that those joints the function of which has to do with locomotion, defense, the acquisition of food and its preparation for assimilation express these principles in terms of the highest mechanical development. The equipment of the knee, hip, shoulder, and temporomaxillary joints exemplifies in varying degrees an architecture designed to give the utmost in efficiency and mobility without sacrifice of stability, an ideal which is attained by an elaborate development of synovial membranes, articular cartilages, and ligaments. Of these, the temporomaxillary is unquestionably the most highly specialized, intricate, and efficient, and may perhaps, for this reason, be regarded as the most important from a biological viewpoint.

At the same time, the increasing structural complexity which goes hand in hand with higher

specialization eventually exacts its penalty in terms of a mechanism more susceptible to disorganization under physiological stress and conceivably accounts for the prevalence of internal derangements in this type of joint.

The temporomaxillary articulation is classed in works on arthrology as a diarthrosis, subdivision ginglymo-arthrodia, signifying a mobile joint capable of executing both a hinge-like and a gliding motion.

The component osseous elements of the joint are the condyle of the inferior maxilla and the glenoid or mandibular fossa of the temporal bone. The former, in cross section, is oblong with long axis transverse and it is set a bit obliquely on the neck in such a manner that its outer edge is a little more forward and a little higher than its inner one. It is acutely convex from before backward and, to a lesser degree, from side to side (Fig. 1).

The squamous portion of the temporal bone provides for articulation with the head of the inferior maxilla, a glenoid fossa bounded in front by the articular eminence and behind by the tympanic plate. The posterior compartment of the fossa lodges a segment of the parotid gland while the anterior or mandibular compartment presents a deep, cartilage covered concavity the radius of curvature of which in the sagittal plane corresponds very closely to the radius of convexity, in the same plane, of the condylar head. The cartilage coating of the articular fossa is continued forward upon the articular eminence so that this joint surface, as represented by the cartilage covered area, assumes on sagittal section a concavoconvex profile (Fig. 3).

Interposed between these bony articular surfaces is the extremely interesting interarticular fibrocartilage or joint meniscus, the structure and relations of which have a particular bearing on the subject in hand.

This meniscus is a thin fibrous plate of oval form, thicker at its circumference, especially behind, than at its center where, indeed, a normal perforation is occasionally found. It is closely and intimately applied to the condylar head and so maintained, in part by its circumferential attachment to the capsular ligament, but more by its relation to the fibers of the external pterygoid muscle which gain an insertion to the neck of the condyle in front and to the corresponding anterior margin of the meniscus as well (Figs. 1 and 3).

A capsular ligament envelops the joint in a thin loose capsule passing from the margins of the glenoid cavity and the articular eminence immediately in front to the upper margin of the interarticular fibrocartilage, and from the lower

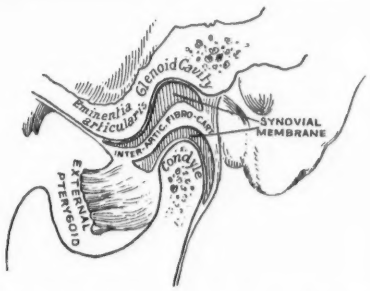

Fig. 3. Vertical section of temporomaxillary articulation to show relations of the condyle, meniscus, synovial cavities, pterygoid muscle, and glenoid fossa. (After Gray.)

margin of this cartilage to the neck of the condyle which it completely invests (Fig. 4).

The joint cavity is thus divided by the interarticular fibrocartilage into two separate and unequal compartments. Both of these compartments are provided with distinct synovial sacs, the upper one of which is much larger and more extensive, and its lining membrane is continued from the margin of the cartilage covering the glenoid cavity and articular eminence and reflected onto the upper surface of the fibrocartilage. The lower and smaller passes from the undersurface of the cartilage to the neck of the condyle (Fig. 3).

This delicate structure is supplemented by three important ligaments designed to stabilize the articulation and confine the mobile condylar head within normal limits. Of these, the external lateral ligament is attached to the outer surface of the zygoma in front of the joint whence it is directed obliquely downward and backward to secure attachment to the outer and posterior border of the neck just below and behind the head (Fig. 4). It quite obviously is designed as a check ligament to limit the posterior excursion of the head and thus tends, not only to prevent posterior dislocations, but endeavors as well to protect the neighboring middle ear.

The stylomandibular ligament extends downward and forward from the tip of the styloid process to the posterior border of the angle of the jaw (Fig. 5) and gains attachment to a point distal to the axis of rotation of the bone. Its mechanical advantage is consequently exerted (1) to check extreme anterior rotation of the jaw and (2) thus indirectly and simultaneously to limit the posterior excursion of the head. The internal lateral ligament, of lesser importance, is so disposed as to stabilize lateral mobility of the inferior maxilla but it, too, by reason of its insertion

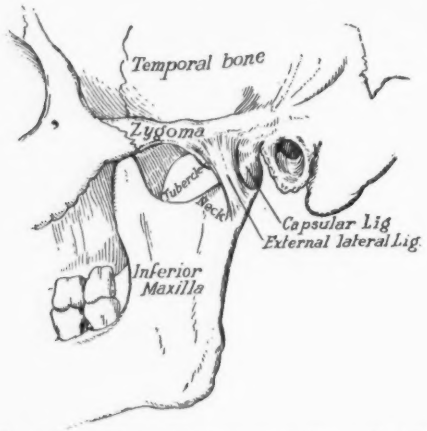

Fig. 4. External aspect of temporomaxillary articulation to show external lateral and capsular ligaments. (After Gray.)

in proximity to the axis of rotation of this bone, undoubtedly is a supporting factor in the movement.

It is therefore apparent that the mechanical disposition of the extrinsic ligaments, together with the posterior thickening of the capsular ligament which is strongest in this region, represent elaborate precautions against the possibility of posterior displacement of the condyle. It is equally apparent that no analogous structure is provided to restrict the degree of posterior rotation of the angle of the inferior maxilla and, in consequence, the excursion of the condyle forward in proximity to the thinnest and weakest portion of the capsular ligament. These structural peculiarities unquestionably bear a causal relation to the prevalent forward luxation of this joint.

This anatomically complex structure is capable of translating itself into a versatility of movement which is seen in no other joint and which resolves itself into three chief and distinct types: (1) a hinge-like motion about a transverse horizontal axis drawn tangentially to the upper articular surfaces of the condylar heads and taking place entirely in the inferior synovial cavity; (2) an anteroposterior gliding movement along a horizontal plane, taking place entirely in the roomy upper compartment between the upper surface of the meniscus and the glenoid cavity; and (3) an oblique rotatory movement made up of two components, (a) a rotatory movement about a vertical axis through each condylar head, confined to the lower synovial compartment, and (b) an oblique gliding movement, confined to the upper compartment, the meniscus gliding forward and inward on one side as it moves backward and inward on the other.

Normal mastication of food, incident to its preparation for the first step of physiological digestion, calls into play all the resources of this mechanism. As the mouth is opened in anticipation of the reception of food, the point of the jaw is depressed, the angle begins to rotate posteriorly while the condyle and major portion of the ascending ramus move forward. The fixed point or axis of rotation of the inferior maxilla, as a whole, is represented by a horizontal line drawn through the two dental foramina.

In effect, the mechanics of this movement suggest a close analogy with those of a lever of which the axis of rotation or fixed point corresponds to the fulcrum; the ascending ramus from the dental foramina to the joint surface corresponds to the short arm; while the horizontal ramus, inclusive of the angle, may be likened to the long arm. Depression of the point of the jaw, the long arm of the lever, is at the outset compensated at the joint—the apex of the short arm—by a hinge-like motion confined to the lower synovial compartment. But as the movement of the long arm carries through, the end of the short arm, obeying the principle of levers, is called upon to travel through an arc proportionate to that described by the end of the long arm. At this point, since the hinge motion of the lower compartment is no longer adequate, the upper compartment comes into action, permitting the condyle with its meniscus to glide forward upon the summit of the cartilage-covered articular eminence. Normally the condyle never passes this summit for, should it do so, it slips over, with its meniscus, into the zygomatic fossa to become a true dislocation. Nevertheless it is to be noted that the margin of safety here is a very narrow one, since there are no evident safeguards, such as those observed posteriorly, to interpose a check upon excessive movement and possible dislocation.

As the inferior maxilla returns to its original position in the shutting movement of the jaw, the condyle glides back with its meniscus in the reverse direction, utilizing the combination of the gliding hinge and rotary motions to give the cutting and tearing power to the incisor teeth.

These structural and functional details relating to the temporomaxillary joint are worthy of consideration in seeking to establish the true nature and etiology of its subluxation.

Cooper believed, as noted above, that the causative factors in this condition comprised the

separation of the meniscus from the condylar head followed by the riding forward of the latter, minus this meniscus, upon the articular eminence. Thus, according to this theory, the gross pathology involved the separation of the meniscus from the head of the bone. Pringle, however, in discussing this point, recalls the fact that, although the generously proportioned superior joint compartment permits free movement in the horizontal plane between cartilage and the surface of the glenoid, the limited lower compartment permits only restricted rotary motion between the cartilage and head of bone. Therefore, while it may be dragged freely in all directions over the condylar head, the cartilage is intimately attached thereto at its periphery and accordingly must accompany the condyle in any position assumed by it. For this reason, complete dislocation of the cartilage alone does not take place and explanation of the phenomena of subluxation on this basis consequently becomes unacceptable.

In offering an alternative explanation, Pringle directs attention to certain significant features in the structure and relations of the cartilage. He refers to the fact that the cartilage, as applied to the dome-like head of the condyle, presents, in the coronal plane and extending over the summit of the dome, a thickened ridge in front of which there is a corresponding depression. Hence, as seen from its lateral aspect, it assumes a concavoconvex surface which fits accurately the reciprocal irregularities of the glenoid fossa. Furthermore, it will be recalled that the powerful internal pterygoid muscle gains an attachment to the antero-internal aspect of the cartilage, thus tending to exert at this point in the loosely applied structure a potential pull the direction of which is forward and inward (Fig. 2).

Utilizing these facts, Pringle suggests the theory that, under certain conditions, e. g., a sneeze with the mouth in the wide open position, a sudden violent contraction of the internal pterygoid muscle may act to displace the loosely applied cartilage so that the thick central ridge lies obliquely instead of transversely. The cartilage then assumes the rôle of a foreign body caught between the rolling condyle and the glenoid surface. The disc is crushed between the opposing bony surfaces and painful locking of the joint is prone to follow. These events produce stretching of the peri-articular tissues promoting recurrence of the same phenomena and giving rise to the annoying snapping noise characteristic of the condition.

This theory is a satisfactory explanation of the causation of the symptoms noted in snapping jaw

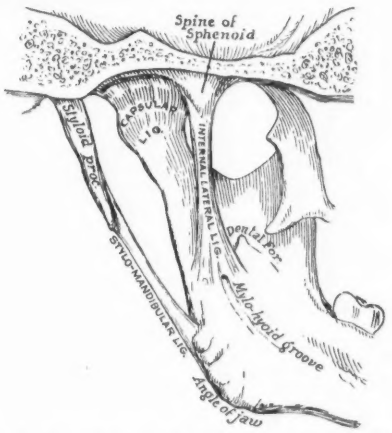

Fig. 5. Internal aspect of temporomaxillary articulation to show internal lateral, capsular, and stylomandibular ligaments. (After Gray.)

and is founded upon actually demonstrable mechanical and anatomical conditions. It is most probable that the majority of clinical examples of this lesion owe at least their inception to some variation of the train of events described.

Nevertheless it is evident that, whatever may be the mechanisms initially concerned, the sum total of their operation is peri-articular relaxation and that several other factors also may enter into the production of this latter condition. The following case may be cited as illustrative of this point:

D. W., a robust male, aged 23 years, was first seen February 1, 1926, in consultation with his physician. In 1920, he had sustained an injury to his lower jaw which was said to have resulted in a fracture dislocation. Upon removal of the retentive dressing applied in treatment of this condition he observed that the left temporomaxillary joint exhibited an unwonted degree of mobility. As time went on, this mobility became gradually more pronounced and every active motion of the lower jaw became associated with a loud snapping noise referred to this joint. Recently the right articulation began to display similar disturbance but to a lesser degree.

Eventually the noise emitted by the left joint became so prominent and constant as to intrude itself annoyingly into the conversation whenever the patient opened his mouth to articulate. So seriously did this state of affairs interfere with his occupation as an insurance salesman that some relief from the embarrassing situation became imperative.

Examination of the affected joint gave but little information. There was no tenderness to pressure and no deformity could be detected. The condylar head upon the left seemed a bit more prominent and the excursion of the head seemed slightly greater than upon the right. Passive motion of the lower jaw with muscles relaxed disclosed very definitely an abnormal laxity in both joints but was particularly marked upon the left. When active motion of the lower jaw took place, as in opening the mouth, a loud snapping noise was

audible throughout the room, as the head of the bone rode over its articular surface. All motions were carried out without pain and there was no limitation to any normal movement.

X-ray examination demonstrated normal joint outlines. With the mouth wide open, the left condylar head rode forward farther on the articular eminence than did the right but no true dislocation could be shown.

Although he was advised that surgical measures offered a very dubious prognosis for cure of this condition, the patient was insistent that some attempt at operative relief be undertaken.

Operation was performed on February 2, 1926, at the Post-Graduate Hospital. General anæsthesia was used. A vertical incision, 2 inches in length, with its upper extremity overlying the root of the zygoma, was made just in front of the auricle. The incision was carried down to the deep fascia and the auriculotemporal nerve and superficial temporal vessels were retracted posteriorly. A transverse incision was made along the inferior margin of the zygoma and carried forward through the deep or external parotid fascia. The parotid gland now could be retracted downward and forward, carrying with it the temporofacial branch of the facial nerve. The joint itself was easily exposed without danger of injury to important neighboring structures. The capsule was found to be extremely relaxed and loose, permitting an unusual degree of mobility to the condylar head within its glenoid cavity. The capsule was incised vertically to expose the interior of the joint which could be readily explored due to the laxity of its capsule. The joint meniscus could not be found and the articular surface of the condyle was roughened and eburnated. For the purpose of limiting the mobility of the condylar head, its articular surface was scarified and, after closing the capsule, a series of "reefing" stitches of chromic gut were inserted. The wound was closed without drainage and the lower jaw immobilized by means of a bandage.

The incision healed uneventfully. On the seventh day after operation, the bandage was loosened to permit some motion of the jaw. On the tenth day the retentive dressing was completely removed and ordinary motion was encouraged. At the end of the second week all functions could be carried out without pain. The joint was perfectly stable, abnormal mobility appeared to be corrected, and the annoying snapping noise had completely disappeared. When last seen, 2 years after operation, the patient had no complaints and was well pleased with the results obtained.

Peri-articular relaxation appears to have been the etiological factor in the symptoms described in this case. Relief of the symptoms was accomplished by joint scarification and plication of the lax capsule. It is probable that the peri-articular relaxation was directly attributable to the loss of the stabilizing action of the joint meniscus whose absence may in turn be traceable to the effects of trauma sustained when the jaw was fractured 6 years previous to the onset of the snapping jaw. It may be surmised that such an injury could have produced fracture or crushing injury of the meniscus sufficient to determine its atrophy and complete dissolution.

Concerning technical details, it is worthy of note that this joint, although superficially placed, is surprisingly inaccessible for satisfactory surgical approach and its adequate exposure presents somewhat of a problem. On the one hand, cosmetic demands limit the incision as to length and location; on the other, certain restrictions are imposed by the proximity of important structures requiring protection. Among the latter may be mentioned the facial nerve (temporofacial branches), superficial temporal vessels, auriculotemporal nerve, and internal maxillary artery.

The facial nerve, after leaving the stylomastoid foramen, passes downward, outward, and forward through the substance of the parotid gland to divide, just posterior to the ascending ramus of the inferior maxilla, into two main terminal groups, the temporofacial and the cervicofacial. The former, running forward and upward in front of the external auditory meatus, passes close to the joint on its antero-inferior aspect (Fig. 6). A line drawn on the surface from the tip of the mastoid to the outer canthus of the eye represents roughly the highest branch of this group of nerves. Close to and in front of the external auditory meatus, the superficial temporal vessels and the auriculotemporal nerve, in their vertical course to the temporal region, pass just posterior to the articulation, although on a more superficial plane.

Thus, as pointed out by Henderson and New, the articulation occupies roughly the center of a triangular area, base upward, bounded by the temporal vessels behind and the temporofacial nerves in front. This triangular area is therefore devoid of superficial structures of importance and through it the joint may be safely exposed.

The internal maxillary artery is deeply placed, passing close to the inner side of the neck of the inferior maxilla, and is therefore not liable to injury during simple arthrotomy procedures.

The conventional incision described for exposure of the joint has been planned with radical excision in mind. Murphy, Lilienthal, Henderson and New, and Annondale employed incisions which, save for unimportant modifications, are identical in principle, i. e., each is a curved, hook-shaped, or right-angled incision, with one limb parallel to the zygoma and the other carried downward in front of the pinna to secure a triangular flap. Burdick, for purposes of joint resection, has modified this incision by the addition of a posterior limb carried back over the ear and is of the opinion that the sacrifice of the temporal vessels thus entailed is more than compensated by the increased effectiveness of the exposure so obtained.

In operations limited to arthrotomy, however, a simple vertical incision in front of the pinna has usually proved to be quite adequate for the purpose in hand. Nevertheless, Ashhurst utilized

in his case of snapping jaw the classical triangular incision, while Blake resorted to a transverse incision along the zygoma only to find that he was unable to carry out the procedure planned through such exposure.

In the case herein reported, I found the vertical skin incision to be quite suitable for purposes of joint exploration and believe that, at least from a cosmetic viewpoint, it possesses considerable advantage.

This incision is carried down to the deep fascia and here an expedient based upon the local anatomy may be utilized to safeguard the temporofacial nerve. Dissections of this region demonstrate that this nerve remains deep to the deep or external parotid fascia until it reaches a point well above the level of the zygoma, where it is seen to pierce this fascia to continue its course superficially (Fig. 6). It will be recalled also that the deep fascia of this region splits below into two layers to enclose the parotid in its fascial capsule, the external and internal leaves of which again unite at the zygoma to become continuous with the temporal fascia.

Keeping in mind these anatomical facts, the operator may widely retract the vertical skin incision and transversely incise the external leaf of the parotid fascia for a distance of 2 inches parallel to and just below the zygoma. The nerve, since it is deep to the fascia at this point, is safe from injury, and the gland, thus freed, may be retracted downward and forward carrying the nerve with it out of the field of operation (Fig. 6).

The actual method of treatment to be applied to the articulation itself in attempting correction of the symptoms of subluxation must necessarily depend upon the gross pathology encountered. Etiological considerations suggest that operative effort must be directed (1) to the meniscus itself, which may call for fixation or removal; and (2) to the unduly mobile condylar head and the abnormally relaxed capsule, the former requiring limitation of its excursion and the latter demanding some expedient to overcome peri-articular laxity. I was fortunate in meeting conditions which responded to simple plication of the capsule. It is improbable, however, that such favorable conditions frequently exist and it appears evident from the large number and wide diversity of methods proposed that none has been universally satisfactory.

The following classification of methods, operative and non-operative, which have been suggested for treatment of subluxation of the inferior maxilla, has been compiled from the literature and gives some conception of the scope of efforts in this direction.

I. Non-operative methods
  A. Dental technical procedures
    1. Outside mouth
      a. Apparatus, fastened around chin and held in position by cap on head, limits chewing motion and depression of point of jaw.
    2. Inside mouth
      a. Splint, fastened to upper and lower jaw with intervening catch hinge, is adjustable to limit motion of lower jaw (Schroeder).
      b. Hard rubber plate, fixed to upper jaw and provided with process pointing to edge of masseter muscle or coronoid process, limits excursion of latter (Fritzsche).
  B. Injection of corrosive fluids into joint (to produce shrinkage of capsule and promote adhesions)
    1. Tincture of iodine (¾ cubic centimeter tincture of iodine injected into joint posteriorly secured permanent cure in case of girl, aged 20 years, reported by Perthes).
    2. Alcohol
II. Operative method
  A. Treatment of capsule
    1. Excision of portion of capsule is followed by suture to overcome redundancy (Perthes).
    2. Simple plication of capsule after exploration of joint takes up redundancy and tightens joint.
  B. Utilizing fascial strip (turned down from temporal region to check excursion of head, as described by Nieden).
  C. Treatment of meniscus
    1. Fixation of disc by suture to periosteum of mandibular fossa (Haeber).
    2. Fixation of disc in vertical position in front of condylar process (Konjetzny).
    3. Removal of the articular disc (Ashhurst).

Of the non-operative methods, those depending for their effectiveness upon the employment of some mechanical apparatus, whether external or internal, to limit the excursion of the lower jaw are open to serious objection. Externally applied mechanisms of the type described above are obviously impracticable, while those splints devised for internal use give rise to pressure ulcers, periosteitis, general discomfort, and pain.

Nieden remarks that resort to methods of this sort indicates either that operative measures must be quite ineffective or that they are too little known, the latter explanation being, in his opinion, the acceptable one. Perthes, however, reports a permanent cure in the case of a girl, aged 16 years, treated 6 months by means of a hard rubber splint of the Fritzsche type.

The injection of corrosive fluids into the joint to secure shrinkage of the capsule and to promote adhesions has some basis in reason and Perthes reports a case in which a cure was obtained by injecting tincture of iodine into the joint capsule posteriorly. This raises the interesting question as to how much the factor of irritation contributes

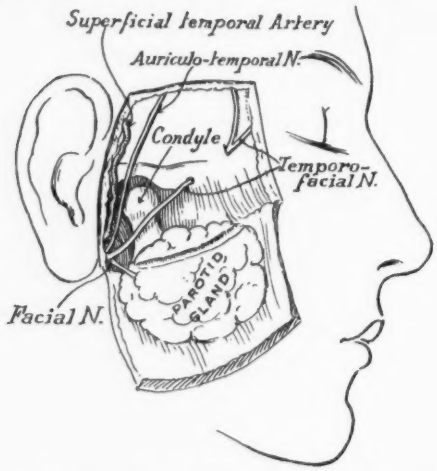

Fig. 6. Schematic drawing from dissection of parotid region. Horizontal incision has been made along lower border of zygoma through the external leaf of the parotid fascia. The parotid is then turned downward and inward after the temporofacial has been dissected free (note groove) in order to permit latter to assume normal relation to the neck of condyle. Note temporofacial nerve piercing fascia above condyle.

Fig. 7. Showing plan of Nieden's operation. Flap of the temporal fascia turned down and sewed to capsule of joint. (After Nieden.)

to produce cure in joints subjected to the trauma of such operations as capsule plication.

Of the operative methods, the procedure of Nieden is based upon the soundest surgical principles. In this operation the joint capsule is exposed through a vertical incision which is then extended upward and backward thus exposing the temporal fascia. A strip of this fascia, with base above the zygoma, is turned downward in such a manner as to permit suture of the free end into the joint capsule thus limiting the excursion of the condylar head (Fig. 7).

Nieden employed this operation successfully in the treatment of a case of bilateral subluxation and was able to demonstrate after operation the functioning of the cheek ligaments whose pull could be plainly felt beneath the skin as the condylar head moved forward during the act of rotation of the inferior maxilla.

This operation and that of simple plication of the joint capsule undoubtedly offer the most effective means available for correction of subluxations dependent upon capsular relaxation and are, therefore, the methods of choice in these cases. Some writers believe, however, that capsular relaxation represents a secondary manifestation of pathology residing in the meniscus and consider that, to be adequate, treatment must be directed at the primary condition.

Haber fixed the disc by suture to the periosteum of the acetabulum and Konjetzny resorted to a more elaborate procedure to fix the disc forward on the condyle. After exposing the joint, he separated the disc from its anterior relations with the capsular wall, the lateral and medial relations being carefully preserved. Some of the upper fibers of the external pterygoid muscle are separated from the condyle and the disc is then displaced forward on the articular head of the bone until it is in a vertical position where it is fixed by sutures. Ashhurst has gone to the extreme of completely removing the disc and reports good results therefrom.

The rationale of fixing the meniscus to the periosteum of its acetabulum is apparent in view of what has gone before and it is equally apparent that operative displacement or actual removal of the cartilage is not free from harmful results. Knowing that this structure equalizes the movements of the condyle and serves by virtue of its elasticity as a buffer between the articular surfaces of the joint, its deliberate forward displacement seems scarcely justifiable under ordinary circumstances. Concerning its actual removal, it may be pointed out that in the case here reported absence of the cartilage seems to have been the factor leading to capsular relaxation and subsequently to subluxation.

In the final analysis it must be said that every case of subluxation must be a rule unto itself, and it is probable that the majority of instances will present pathological conditions which will require

treatment of both capsular and meniscus derangements if satisfactory results are to be obtained.

It is worthy of note that modern joint surgery in general, under the influence of accumulating experience and perfected technical detail, has shown a tendency to widen its scope of operability. Operative indications, which were formerly limited to the more grave pathological conditions, have been gradually extended to include a variety of derangements the minor character of which did not justify the hazards imposed by the older methods. The acceptance of the minor joint lesions for radical surgical treatment indicates the highest degree of confidence in the safety and efficiency of the methods employed and offers as well the most convincing evidence of the advances made in this field.

The temporomaxillary joint, however, has been slow to profit by this development, and there still exists a very evident reluctance to apply to this joint the principles which have proved their safety and effectiveness in analogous minor lesions of the knee, hip, and shoulder.

Glancing over the list of measures proposed for treatment of temporomaxillary subluxation, one is impressed by the number of methods and the diversity of principle represented. Under ordinary circumstances such a state of affairs spells the complete failure of all suggested methods to solve satisfactorily the problems presented and this interpretation may not be unjustified in this instance. Nevertheless, it appears to the writer that the true explanation must be sought in the failure to recognize the pathological physiology of this condition. If the choice of treatment be predicated upon a study of the normal mechanics of the joint and of the factors underlying subluxation, the selection of the method will be limited to those few operations emphasized above, which are competent to cope with the physical principles involved. Wider usage of these methods will prove their practical utility and will demonstrate that numerous cases of temporomaxillary subluxation which have been habitually rejected may be accepted for treatment with every assurance of a satisfactory result.

SUMMARY

In conclusion, therefore, the present status of temporomaxillary subluxation may be summarized as follows:

1. Temporomaxillary subluxation is a definitely distinct entity the pathological condition of which is characterized by a distortion of the normal relations of the joint meniscus leading to capsular relaxation. Resulting disturbances in joint mechanics are responsible for a variety of joint dysfunction best known as snapping jaw.

2. Commonly seen as a painless, noisily functioning joint the efficiency of which is not at all impaired, it is occasionally encountered in the form of chronically recurring attacks of pain and locking, requiring immediate treatment.

3. There exists an unexplained reluctance to apply to this joint the radical operative measures which have become the accepted treatment for analogous minor lesions of other joints.

4. Failure to take into consideration the pathological physiology of temporomaxillary subluxation has been responsible for a large number of proposed methods of treatment representing a wide divergence of principles.

5. Two methods of treatment are emphasized which are based upon sound surgical principles and upon a study of the mechanics of the joint.

6. Utilization of these methods should standardize treatment and demonstrate the practicability of accepting a larger group of these cases for radical operation.

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POST-RADIATION PREGNANCY

Report of a Case

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So much confusion and controversy exist regarding the effect of X-rays on the female and her offspring that many physicians are prone either to withhold the therapeutic use of the X-ray, or to use it only as a last resort in hopelessly diseased conditions. It is well known that the X-rays have proved beneficial in the treatment of pathological gynecological conditions where a repressive action is desired, and its use in such cases is considered proper procedure. But in the treatment of functional female disorders, especially where subsequent pregnancies are desired, such use has not as yet met with universal approval. The occasional unfortunate malformation of offspring born of irradiated mothers has been heralded as a positive contra-indication for its use in the case of women with childbearing possibilities. An attempt has been made to apply the conclusions of radiation's ill effects on lower animals to humans; but as yet no proof has been authenticated justifying such interpretations of these phenomena, nor are we sure that the response of tissues of the different species to identical irradiation is the same.

As proof of the evil effects of radiation, Murphy cites his study of statistics of malformed offspring of irradiated mothers, and there are indeed many instances (16) reported in the literature of the birth of abnormal children following irradiation of the mother. In all these cases, however, radiation was given during the course of pregnancy, and we may explain these occurrences from our knowledge that as radiation is most effective in destroying embryonic tissue, the fetus is the first to suffer. That a radiated fetus is usually impaired *in utero* has been shown by Ries, Zappert, and Rames, although Kane reports a normal child following radium therapy during pregnancy. In its employment for the treatment of functional disturbances of the ovary and for sterility, however, we attempt to limit the radiation action primarily to the ovary, and that normal children may be born following such radiation of the ovary has been reported by Rubin, Rongy, Martius, Doederlein, the present writer, and others. Whether or not an ovary so irradiated as to suppress the menstrual phenomena for a more or less extended period of time can recover so as to produce again, healthy ova which are capable of fertilization and development into normal children is not so definitely proved, yet such occurrences as have been reported especially by Doederlein and Schmitt, would seem, however, to bear out this assumption.

In connection with this question, one must consider the permanency of such suppression of ovarian function. Not all the factors which limit our ability to suppress ovarian function by X-rays are determined. Béclère suggests that there is an age limit to permanency of roentgen castration. Stern, in his work on irradiation of fibroids, noted the difficulty in producing amenorrhœa in young women. Penzoldt is of the opinion that the injury to the ovum may continue up to 4 months after irradiation of the ovary, and therefore impregnation within that time may lead to the formation of an imperfect fetus, but ova occurring with later menstruation may be normal and allow for natural impregnation and subsequent normal fetal development.

Titus has reported normal pregnancy in the case of carcinoma of the cervix treated by radiation. In 1928 I reported a case of twin pregnancy occurring after a temporary amenorrhœa of 7 months, removed by operative procedure, and as far as histological examination could show the developing embryos were evidently normal before operation.

It is well known that pregnancy tends to debilitate patients suffering from acute tuberculosis, especially where frequent pulmonary hæmorrhage occurs. For this reason in such conditions, abortion is usually advised. Until now, surgical emptying of the uterus has been the method employed, but following upon the report of the successful work done by Weyser and Mayer in therapeutic abortion by X-ray irradiation, this latter method has been suggested by our service at Bellevue Hospital, for the handling of such cases.

In the case reported herewith, there existed a severe acute pulmonary tuberculosis with recurrent hæmorrhages.

M. F., married, aged 30 years, entered the hospital, February, 1927, complaining of pains in chest and hæm-

orrhages from the mouth. She was 3½ months pregnant. She has one living child 8 years old, and has had three miscarriages. On account of her pulmonary condition, she was advised to have her pregnancy terminated. She received roentgen-ray treatment over the pelvis. The dosage was 75 per cent anteriorly and 50 per cent posteriorly. A skin erythema dose was delivered by high voltage, heavily filtered X-rays over a period of 14 days. Spontaneous abortion failing to occur in 6 weeks, the uterus was surgically emptied through simple vaginal hysterotomy, on April 11, 1927. Following her operation she did not again menstruate, and did not return to the clinic. When she did return on April 20, 1928, there were evident signs of pregnancy, in our opinion of 2 to 3 months. The question then arose as to the advisability of permitting her to carry on. Inasmuch as the temporary amenorrhœa had benefited her general condition and no pulmonary hæmorrhages had occurred during that time it was decided to let her proceed with the pregnancy, provided that by reason of the previous irradiation the fetus was not damaged and would develop normally. We felt reasonably sure no damage had occurred to the fetus, and she so assured the mother. She proceeded normally with the pregnancy, and on October 27, 1928, gave birth to a perfectly normal male child weighing 7½ pounds. There was no difficulty in the delivery. Today, 14 months: following birth, the child is hale and hearty, and is altogether normal in development.

Fig. 1. Post-radiation baby at 11 months of age. The child is perfectly normal, active, in excellent health, and has 8 teeth.

CONCLUSIONS

Permanent amenorrhœa in young women is not certain to be produced with X-rays.

Not all ova may be destroyed by the X-ray castration in young women, and any such ova not destroyed, may normally ripen, become impregnated, and develop into a normal healthy child.

Abnormality in a child so born has not been noted.

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PREMEDICATION FOR LOCAL ANÆSTHESIA WITH INTRAVENOUS BARBITURIC COMPOUNDS[1]

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THE search for improvement in local anæsthetic methods must necessarily take two directions. Prolongation of the duration of the usual procaine-epinephrin anæsthesia is one aim of further progress. This subject has been taken up in a previous communication (2) and a further report on the use of the suggested quinine derivative will be made in the future (3).

The preparation of the patient for an operation under local anæsthesia is another important problem. The psychic reaction of the patient, his fear and nervous tension in the operating room, may render the best local anæsthesia unsuccessful. This is particularly true of the nervous, irritable patient, especially the hyperthyroid. The usual preparation with morphine-atropine may not always satisfy in patients under high tension. Morphine is an excellent analgesic but, in the absence of pain, it may only nauseate the patient or he may become highly sensitive and irritable. Atropine causes a dryness of the throat and, while the suppression of the bronchial secretion and the diminution of vagal reflexes are welcome under general anæsthesia, the discomfort of the atropinized conscious patient is considerable. The use of scopolamine in doses of 1/200 grain to 1/300 grain is a great help but may occasionally produce toxic symptoms. Hallucinations, restlessness, and poor co-operation have been observed in youthful hyperthyroid patients. Scopolamine is most useful in prostatic cases in older patients, who slumber peacefully under a sometimes imperfect sacral block.

For several years I have been trying to find a suitable drug which would produce somnolence or superficial sleep, without lessening the co-operation of the patient, and producing a deep anæsthesia. A number of papers from French and German clinics report deep surgical anæsthesia following the intravenous use of barbituric acid compounds. An article by Cleisz lists the French literature up to 1924. He describes 40 obstetrical cases and believes that the injection of 6 to 10 cubic centimeters of somnifen, a mixture of diethyl and dipropenyl barbituric acid, is the best analgesic method in childbirth. A number of other French gynecologists praise the value of this barbituric mixture. In Germany the method has been given a thorough trial by Siegert, who injected from 2 to 8 cubic centimeters of somnifen intramuscularly. There were many untoward symptoms and he concluded that the method was not applicable in gynecology.

From this and other reports it seemed wise to me not to aim at a deep surgical anæsthesia but rather to use small doses in preparation for local anæsthesia.

It is sufficiently known that the safety margin of the hypnotics of the barbituric acid series varies a great deal. In a study of 350 albino rats Nielsen, Higgins, and Spruth determined the safety margin of barbituric compounds as the difference between the minimum effective dose and the minimum fatal dose, expressed in the percentage of the minimum fatal dose. From this study it appeared to me that barbital and luminal in particular had a comparatively small safety margin and that neonal was best fitted for my purpose (Fig. 1).

METHOD OF EXPERIMENTS

In the first series of experiments, conducted in 1925, 10 patients were injected intravenously with 2 cubic centimeters of a 20 per cent somnifen solution (Table 1). This uniform dose was given in order to observe the relation of the sedative effect to age, sex, and weight.

While youth, female sex, and light weight may increase the effect of the drug to a certain extent, the individual response seemed to outweigh any other factor. The maximal drop in pulse was 14 points, in respiration 5 points, in systolic blood pressure 11 points, and in diastolic blood pressure 7 points, as an average in 10 cases. This drop is within the normal limits of what occurs in sleep and started 10 to 15 minutes after the injection. An immediate drop after the injection, which would mean a direct influence on the vasomotor and respiratory centers, did not occur in this series.

There was one complete failure (Case 10) in a patient with inoperable carcinoma of the uterus, who had been taking morphine and sedatives for a long time. In a girl, aged 18 years, dehydrated and under weight (Case 2), a deep sleep followed the injection. In the other cases somnolence or light superficial sleep was induced in 9 minutes and lasted 48 minutes on the average. In both

[1]Presented at the meeting of the Society of Clinical Surgery, October 23, 1926, in Chicago.

cases of hyperthyroidism the effect wore off more rapidly, probably owing to the more rapid elimination in these patients. Case 7, after a superficial sleep for 10 minutes, got greatly excited, tossed about in bed, and showed a typical paradox reaction. She had been dismissed from an insane asylum 4 weeks previously. Such reactions will occur with morphine, luminal, and scopolamine, too. In Case 9 an interesting amnesia was obtained in regard to the operation, although during the operation the patient answered clearly my inquiries concerning the recurrent nerve.

On the whole, there was a definite effect, without any untoward symptoms, to be noted in the series. The effect, however, wore off too soon and its action was difficult to foretell. It must be remembered that the dose was only one-fourth of that recommended for deep surgical anæsthesia.

In the second series neonal, in amounts varying from 20 to 60 centigrams, was given intravenously (Table II). There are interesting points to be noted here. In a case of hyperthyroidism (Case 13 we obtained a good effect which was produced very rapidly and wore off in 20 minutes. The dose was only 20 centigrams. The same patient with the same dose was greatly excited in the operating room and a general anæsthesia had to be given. In the case of a man with degenerative stigmata absolutely no effect was obtained with 30 and 50 centigrams (Case 14).

In Case 17, a patient who had carcinoma of the cæcum with metastases was given 60 centigrams of neonal intravenously. The effect was instantaneous. He fell into a deep surgical anæsthesia, with no corneal reflexes, which lasted 50 minutes, and then slept, whenever left alone, during the next 14 hours. His systolic blood pressure dropped from 138 to 96, the diastolic from 110 to 82. His pulse remained full and regular, dropping only 20 points. The respiration dropped 6 points. His condition did not look alarming, except for a slight cyanosis of his finger tips. Cyanosis was observed also in Case 14, that of a man who was operated upon, under local anæsthesia, for an inguinal hernia. The cyanosis could not have been due to cardiac failure in either case but must have been due to an incomplete oxidation of hæmoglobin.

In the third series of experiments subcutaneous injections were tried (Table III). Two cubic centimeters of a 15 per cent solution of neonal were injected into 7 patients. The injections were painful and left marked infiltrations for several days. One patient, although co-operative during thyroidectomy, had a complete amnesia concerning the operation. She developed a generalized

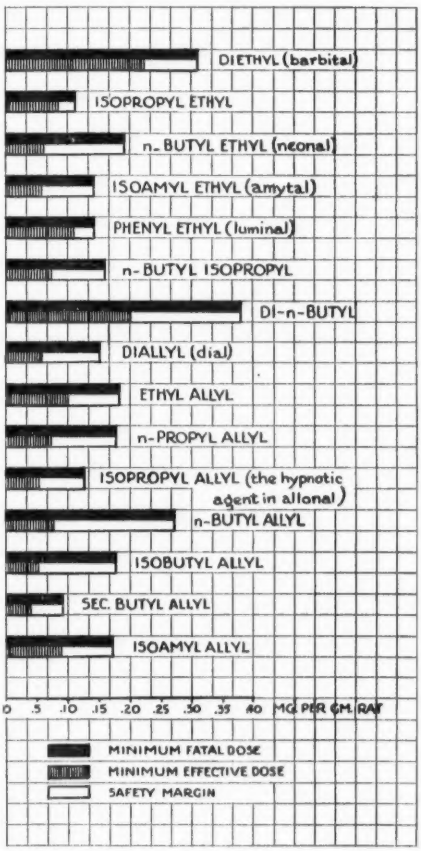

Fig. 1. Safety margin of barbituric compounds from Nielsen, Higgins, and Spruth.

urticaria, probably the effect of medication, on the fourth day after operation. Three patients showed no effect at all. Another three were hardly affected.

In the fourth series oral medication was tried (Table IV). In addition to the customary dose of 20 centigrams (3 grains) of neonal or allonal the night before the operation, I administered 20 centigrams three times on the day preceding the operation. Thus the patient received 20 centigrams in the morning, 20 centigrams at noon, and 40 centigrams in the evening. If necessary another dose of 20 centigrams was given 2 hours before the operation. The patient thus received a gram of neonal in 24 hours, which is a considerable dose because the drug tends to accumulate in the body. In this series, 5 patients were not

TABLE I.—EFFECT OF ONE AMPOULE OF SOMNIFEN GIVEN INTRAVENOUSLY*

Case	Name	Sex	Age	Weight in kilograms	Diagnosis	Maximal drop in			Effect †	Onset minutes	Duration minutes	Remarks
						Pulse	Respiration	Blood pressure				
1	A.G.	M	30	86	Inguinal hernia	12	..	5–10	2	10	30	
2	K.E.	F	18	65	Cæcal fistula	15	6	20–10	3	10	60	
3	J.V.	F	50	90	Cholelithiasis	15	10	10–15	1	10	60	
4	J.J.	F	48	85	Acute appendicitis	19	6	10–5	1	15	50	
5	S.R.	F	36	67	Tracheal fistula	20	2	5–5	1	10	120	
6	L.P.	F	41	70	Appendectomy 10 days ago	8	9	5–5	1	10	60	
7	B.S.	F	28	56	Epigastric pain; hysteria	Plus 20	Plus 20	20–10	2 —2	10	30	Superficial sleep for 10′, became restless, cried and laughed, complained of dry throat.
8	R.G.	F	32	55	Exophthalmic goiter; basal metabolic rate, +40%	20	4	15–10	1	5	20	
9	S.T.	F	49	50	Hyperthyroid under iodine +15% at op.	12	4	16–8	1	15	40	Perfect amnesia concerning operation.
10	M.P.	F	48	55	Carcinoma of uterus	2	2	6–+4	0	..	..	Had had lots of morphine and other sedatives.
					Average drop	14	5	11–7				

*1 ampoule—2 cubic centimeters of a 20 per cent solution (40 centigrams) of diethyl and dipropenyl barbituric acid.
†—1, excited, restless; —2, greatly excited, irrational; 0, no effect; 1, sleepy; 2, sleeps if left alone; 3, deep sleep with preserved reflexes; 4, deep anæsthesia, no corneal reflexes.

TABLE II.—EFFECT OF NEONAL INTRAVENOUSLY*

Case	Name	Sex	Age	Wt. in kilograms	Diagnosis	Dose	Maximal drop in			Effect †	Onset minutes	Duration minutes	Remarks
							Pulse	Respiration	Blood pressure				
11	E.W.	M	38	73	Anal fistula	2 c.cm. 10%	7	2	12–10	2	10	30	
12	M.K.	F	18	47	Exophthalmic goiter, basal metabolic rate, +45%	2 c.cm. 10%	..	..	0–10	2	3	20	
13	Same	F	18	47	Exophthalmic goiter; operating room	2 c.cm. 10%	..	..	..	—2	..	..	Greatly excited, had to be put to sleep.
14	A.H.	M	34	50	Inguinal hernia	3 c.cm 10%	6	2	0–0	0	..	..	
15	Same	M	34	50	Inguinal hernia	5 c.cm. 10%	4	1	5–3	0	..	..	
16	G.H.	F	44	50	..	2 c.cm. 10%	2	2	0–0	2	10	30	
17	W.E.	M	65	..	Carcinoma of cæcum with metastases	4 c.cm. 15%	20	6	42–28	4 2	0	50 14 hr.	Deep surgical anæsthesia. Slept if not aroused.
18	D.M.	F	23	47	Tuberculosis of cervical glands	1.5c.cm. 15%	5	2	10–5	—1 2	15	20	First cried, then slept.
					Average drop		6	2	9–7				

*Ampoules of 10 per cent and 15 per cent of N-butyl-ethyl-barbituric acid.
†Scored as explained in footnote to Table I.

affected at all, and only 3 showed a real sedative effect. The disadvantage of keeping the patient in a somnolent state the day before the operation will be discussed later.

DISCUSSION

A report on the 35 cases shown in the tables would hardly seem warranted. However, as I have discontinued this premedication and as, recently, renewed interest is being shown in intravenous hypnotics, publication seems worth while in spite of the paucity of data.

The outstanding feature of the barbituric acid series, particularly in intravenous dosage, is the difficulty of foretelling the individual response. The patient's age, sex, and weight influence the

TABLE III.—EFFECT OF SUBCUTANEOUS NEONAL INJECTIONS IN 15 PER CENT SOLUTION

Case	Name	Sex	Age	Weight in kilograms	Diagnosis	Dose	Effect*	Remarks
19	S.S.	F	52	61	Diffuse colloid goiter	2 c.cm. 15%	1	Extensive rash on fourth day; amnesia concerning operation.
20	S.F.	F	55	70	Ventral hernia	2 c.cm. 15%	0	Had taken allonal for several weeks.
21	P.T.	M	60	55	Duodenal ulcer	2 c.cm.	1	Sleepy but became wide awake in operating room.
22	D. S.	F	35	61	Hæmorrhoids	2 c.cm.	0	No effect.
23	M.D.	F	55	62	Inguinal hernia	2 c.cm.	0	
24	G.T.	M	40	65	Amputation for gangrene	2 c.cm.	1	Slight sedative effect.
25	R.S.	M	55	63	Trophic ulcers on leg; periarterial sympathectomy	2 c.cm.	1	Slight sedative effect.

*Scored as explained in footnote to Table I.

TABLE IV.—EFFECT OF ORAL DOSES OF NEONAL ON PRE-OPERATIVE CASES*

Case	Name	Sex	Age	Weight in kilograms	Diagnosis	Effect†	Remarks
26	G. S.	M	70	66	Carcinoma of glands of neck	0	Nerve block was successful but patient showed no sedative effect.
27	M.K.	F	18	47	Exophthalmic goiter	0	Same patient in bed 2 days earlier showed marked somnolence.
28	M.P.	F	54	78	Ventral hernia	1	Sleepy after 1 hr., later talkative.
29	Same	F	54	78	Ventral hernia; after operation	2	Marked sedative effect in the room.
30	E.T.	F	20	61	Exophthalmic goiter	2	Good pre-operative state.
31	L.P.	M	70	65	Hypertrophy of prostate	0	
32	T.S.	M	38	56	Lipoma of back	0	
33	M.L.	M	49	55	Bleeding gastric ulcer; hæmoglobin, 25%	2	Marked effect during the entire day.
34	M.S.	M	51	60	Abscess of thigh	1	Slight effect.
35	R.C.	M	59	58	Diabetic gangrene	0	

*1 gram of neonal in 24 hours.
†Scored as explained in footnote to Table I.

dosage to some extent, but more important is the amount of anxiety which is to be overcome. An 18 year old girl with exophthalmic goiter, became quite sleepy after the injection of 2 cubic centimeters of 10 per cent neonal (Case 12). The same patient a few days later received the same dose and was taken to the operating room, where she became greatly excited and had to be put to sleep (Case 13). A similar experiment was made on a woman, aged 54 years, who reacted differently in her room from what she did in the operating room (Case 28).

The intravenous dosage in this series was about one-fourth to one-fifth of what had been recommended for obtaining deep surgical anæsthesia. In Case 17, however, a dose of 60 centigrams of neonal (4 cubic centimeters in 15 per cent solution) resulted in deep surgical anæsthesia for 50 minutes, followed by a deep sleep for 14 hours. While the pulse and blood pressure did not drop to an alarming degree, a slight cyanosis was present. It was after this experience that I decided to give up the intravenous medication. In a young woman, weighing 56 kilograms, a dose of 40 centigrams of somnifen produced great restlessness, excitement, flushing of the face, and dryness of the throat. Such individual and previously inestimable reactions make very difficult the use of intravenous sedatives, at least that of the two drugs which I employed. The effect wears off, in most cases, very rapidly, whereas the anæsthesia sets in very quickly.

The subcutaneous medication was soon abandoned, because of the pain at the site of injections and because of the slow absorption of the drug into the blood stream, which made impossible its accumulation in satisfactory concentration. Perhaps intramuscular injections could be tried, as

used by Siegert, to obviate the pain accompanying subcutaneous injections.

The protracted oral medication resulted in just as many different individual responses as did the other forms of administration. Furthermore, to produce a sedative effect, the patients were kept in a somnolent state an entire day before operation, which hardly seems desirable. Their nutrition is thus impaired and the glycogen storage of the liver cannot be so well maintained. Prolonged sleep after the operation is equally undesirable. The patients are more apt to develop pulmonary complications and their nutrition, unless subcutaneous and rectal medication is resorted to, is impossible. It is well known that patients who take barbital for suicidal purposes quite frequently develop pneumonia.

On the basis of these few experiments, I hesitate to say that analgesia or light sleep produced by barbituric acids is not feasible. With larger doses, I could readily have induced deep anæsthesia, as was obtained in one case. I feel, however, that the advantage of inducing a rapid surgical anæsthesia by the help of intravenous medication is offset by the uncertainty of the effect, by the prolonged sleep as in true barbituric acid poisoning, and by the inability to stop or counteract the effect of the anæsthetic. This, of course, is the difficulty with all intravenous and rectal hypnotics.

There is only one type of case in which intravenous administration of the barbituric series seems well worth while. Hofvendahl advised intramuscular injections of 2 to 4 cubic centimeters of somnifen in cases of cocaine poisoning. Tatum and his co-workers found that the minimal fatal subcutaneous dose of cocaine in the dog was 26.7 milligrams per kilogram. This minimal fatal dose could be raised to above 100 milligrams per kilogram weight with the prophylactic administration of a mixture of barbital sodium and paraldehyde. Hence a fourfold increase in tolerance to cocaine resulted. Convulsions were completely and instantaneously controlled by an intravenous injection of the barbital-paraldehyde mixture. In addition, however, Dragstedt and Lang found that atropine would exert the same protective influence in case of cocaine poisoning.

It might be well worth while to consider an intravenous injection of one of the soluble barbituric acid derivatives, such as somnifen, neonal, or amytal, in cases of acute novocaine poisoning, with convulsions, which almost invariably is the result of an intravenous injection. On the basis of Dragstedt and Lang's study it would appear that atropine could also be used.

SUMMARY

An attempt to produce, in patients operated upon under local anæsthesia, a state of somnolence or light sleep by means of intravenous, subcutaneous, and oral doses of hypnotics of the barbituric acid series, is described. Because of great individual variations, this attempt was not successful and was given up after trial in 35 cases. It is possible that larger doses and other derivatives may give a more uniform effect. The protective action of the barbituric compounds against poisoning with cocaine and its derivatives is pointed out.

NOTE.—The patients were selected from my service at the Surgical Clinic of the University of Budapest and at the Wesley Memorial Hospital, Chicago. Drs. Allen B. Kanavel and Charles A. Elliot kindly permitted the use of some of their cases for which many thanks are due.

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THE ANTHROPOLOGY OF THE NEGRO, ITS BEARING ON THE MORTALITY IN HEAD INJURIES

A Review of Six Hundred Cases

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WITH the development of fast moving, high powered automobiles and the simultaneous appearance of a tragic disregard for law and the rights of others, the number of head injuries is rapidly increasing year by year, and the negro is receiving more than his proportionate share of such injuries. This is the result not only of his lesser degree of judgment—in many instances decreased by alcoholic intoxication—but also of his at least equal, if not greater, amount of indifferent recklessness.

For generations head injuries, especially fractures of the skull, have been viewed by the layman particularly as a most melancholy affair. There is no gainsaying the fact that, even with the more scientific management of today, head injuries frequently have a tragic ending.

When one contemplates, from an anatomical point of view, the infinite care with which the brain and spinal cord have been protected—the skull, enclosing the entire brain, thickened where the impact is most likely to land; the dural covering, the strongest membrane in the body, limiting turgescence and affording physiological rest; and the choroid plexus, a safeguard against infection—it prompts the conclusion that the brain, with its myriads of delicate nerve fibers, is, of all the organs of the body, least capable to care for itself.

My first memory of fear was occasioned by a negro idiot, Buck King by name, in my native county of Upson. He had flat feet, his skull was of the scaphocephaloid type, and his lips were thick and protruding—the lower lip even drooping. His head was his only weapon and he revenged all his imaginary grievances by pinning against a wall the person whom he took to be the offender and butting him in the abdomen. My knowledge of this characteristic was no doubt the foundation of my well grounded opinion that a negro head would withstand much punishment. This idea seems prevalent throughout the southern states, and doubtless has existed for many years, for in Dr. S. Weir Mitchell's *Youth of George Washington* the following incident illustrates this belief:

"I had been told, of a Sunday morning, of a great flock of ducks, of the kind called canvasback, and much esteemed. It was against our habits to shoot on this day, but towards evening, the temptation being great, I went to the shore and was about to push off, when Peter, using the liberty of an old family servant, said I would make Mr. Fairfax and my brother, then like myself at Belvoir, angry if I went. When he held on to the prow to stay me, I suddenly lost my temper and struck him with an oar on the head. He fell down and lay in a sort of a shake. I thought he was killed, and had he been white I must surely have put an end to him; but the blacks have thick skulls, and presently he got up and staggered away, his head bleeding."

Prompted by this statement and the knowledge that the Surgeon General's Library possessed no literature on this particular phase of head injuries, I concluded it would be interesting and timely to take advantage of the excellent opportunities afforded me to make a clinical study of a long run of head injuries in negroes, as compared with an equal number of similar cases in whites, in order to determine if there were any clinical foundation for this prevalent idea that a negro's head was more difficult to injure than a white man's.

It is an established rule in physics that a hollow sphere of smaller diameter will stand more stress and strain than a sphere of equal thickness but of greater diameter. That being true, it stands to reason that if the smaller sphere is also thicker, the resisting strength will be increased in direct proportion to the thickness. As to the size and thickness of the negro skull, no less an authority than Hrdlicka, of the Smithsonian Institution, says: "It is quite true that the skull of the American negro, and that particularly where there is some scaphocephaly, is thicker than that of a white man. The excess, however, differs: on the average I should say the negro skull is at least one-third thicker than that of the average white American. As to the size of the negro skull, it is generally smaller than that of the white man, stature for stature."

A. H. Keane (5), of London, says: "The chief points in which the negro either approaches the Quadrumana or differs most from his congeners, are among others, No. 3, Weight of brain, as

indicating cranial capacity, 35 ounces, highest gorilla 20 ounces, average European 45 ounces. No. 8, Exceedingly thick cranium enabling the negro to butt with head and resist blows which would inevitably break any ordinary European's skull."

Davis makes the following statement: "The skull is thinner in the white than in the negro race," while Brinton, in *Races and People*, states that cerebral or cranial capacity has been proved by investigation to average less in the negroes than in the whites. To be more exact, the average weight of the white man's brain is 1,475 grams, of the negro's brain, 1,331 grams.

Trotter, in writing on the vulnerability of the brain, mentions Spencer's pioneer investigations of cerebral hæmorrhage in the newborn some 30 years ago and continues: "We have seen that the European skull does not protect the enclosed brain from injury so efficiently as does the African skull. This must be because the latter is the stronger and more rigid. . . . From the anatomical point of view this superior strength is evidently not very striking, since, as far as I know, it has attracted but little attention and led to no attempt being made to measure it. From the functional and medical point of view the superior strength of the African skull is at once obvious and is plainly a very important racial character. The relative slightness and flexibility of the European cranium is then a leading character of the race and brings with it gross functional disadvantages in the resistance of injury."

Thus we are again face to face with the inevitable law of compensation: while the Caucasian is endowed with better reasoning power than the negro's to enable him to avoid injury, the skull of the negro offers much greater resistance to injury than does the skull of the white man.

Since it is known that a hollow sphere of a certain diameter withstands more stress and strain than a sphere of larger diameter; that the highest authorities agree that the negro's skull is not only smaller, but also thicker, than the white man's; that the relative slightness and flexibility of the Caucasian's skull brings with it gross functional disadvantage in the resistance of injury; that Bean, in his measurement of 103 brains and study of 10,000 individuals, has classed the southern negro with the Guinea Coast negro, "the most ancient and the most classical negro type"—it is a logical deduction that study of a large series of head injuries in negroes in the South would show the effects accurately, with a decidedly small death rate as compared to that in an equal number of such injuries in the whites.

With a view of obtaining the most accurate statistics possible, 300 cases in the white race have been compared with 300 cases in the negro. To these two groups of cases there has been applied the same classification of injuries resulting from practically the same causes and the same underlying principles have governed the type of treatment in both groups.

Only cases showing definite brain damage, such as bloody spinal fluid, fractures, unconsciousness semi-consciousness, bleeding at ears, paralyses, exophthalmos, tinnitus, aphasia, nystagmus, vomiting, have been considered.

The same routine study has been made in every case: a rough neurological examination; several blood pressure readings at short intervals; roentgen-ray examinations of skull showing antero-posterior and lateral stereoscopic views; spinal puncture to detect blood in the fluid; spinal fluid pressure reading with an Ayer manometer; and opthalmoscopic examinations of eye grounds.

TREATMENT

Frequently patients with head injuries when first seen are in a state of profound shock. Regardless of the type of injury, the shock must be combated until the patient reacts favorably, before routine examination is attempted.

In head injuries, two types of disturbance should be considered and examination when completed should enable one to classify a given case in one or the other of two groups: (1) that caused directly by the force of the blow and showing immediate symptoms, such as hæmorrhage, concussion with temporary unconsciousness, and depressed fracture with possible localized paralysis, torn dura, and contused brain; and (2) that resulting from external force but never coming on instantaneously, but after certain intervals manifesting themselves either by hæmorrhage or gradually developing œdema of the brain. In other words, head injuries may be divided into two main groups: (1) operative and (2) non-operative. In the operative cases, surgical interference is resorted to only when there is something to be removed, such as a large blood clot, depressed bone, badly damaged brain tissue, or a subdural accumulation of fluid. Among the non-operative cases are those of simple concussion or potential brain damage with or without fracture, which experience teaches will recover with the help of dehydration and a hypertonic diet—the larger group of cases.

Given a patient with a head injury, who is semiconscious or unconscious, possibly with a linear fracture, perhaps with bleeding from one ear, with bloody spinal fluid, but with blood pressure nor-

mal or only moderately elevated, one may reasonably expect recovery with dehydration and hypertonic diet. Adults are given ½ ounce of a saturated solution of magnesium sulphate every 3 hours for 24 hours, then the same dose every 4 hours for another day, gradually lengthening the intervals daily for 1 week, when the magnesium sulphate may generally be discontinued. The dose for children should be regulated according to age, 1 to 2 drachms every 4 hours. Should magnesium sulphate cause too frequent evacuations, they may be controlled with paregoric or a small dose of codeine. If the patient cannot swallow, 10 cubic centimeters of a 10 per cent solution of magnesium sulphate may be given intravenously daily.

The diet should be a combination of hypertonic and dry: very sweet fruit ades, salty broths, dry foods, and no plain water.

Spinal punctures should be made daily until spinal fluid clears up. Luminal or bromides are to be given for extreme restlessness.

A bleeding ear should never be syringed out. Instead it should be wiped out with sterile cotton, a few drops of a suitable antiseptic introduced, and the canal kept plugged with sterile cotton.

Patients with wild delirium must sometimes be restrained; they should be isolated from all relatives and kept quiet by retention enemas of 2 drachms of paraldehyde in milk or water according to circumstances.

Frequently the irritative stage of a large hæmorrhage closely resembles alcoholic excitement; the venous engorgement resulting from increased pressure causes the patient to become irritable, excited, and even resentful. Careful watching of these patients for several hours may prevent a very embarrassing situation.

Patients with ruptured meningeal artery and depressed fracture should be operated upon. A torn dura and contused brain is often found associated with such fractures. One of the delayed conditions is a subdural accumulation of bloody fluid which manifests itself either by increase of intracranial pressure or by localized irritative symptoms, such as the jerking of a hand or foot.

Probably the type of case which most urgently calls for operative interference is the middle meningeal hæmorrhage, in which the patient shows a temporary unconsciousness followed by an interval of consciousness, a slow bounding pulse following a slightly rapid small pulse, a gradual relapse into unconsciousness, with stertorous, snoring breathing and perhaps a gradually developing hemiplegia or contralateral convulsions. These patients demand immediate subtemporal decompression with ligation of the ruptured meningeal artery. The patients with subdural accumulation of fluid also call for this type of operation, in which the dura is opened to allow the fluid to escape. A typical case of several days' standing might be relieved by a small trephine opening with a small opening in the dura.

Depressed fracture should be trephined away, the dura opened, clots removed, and damaged brain tissue removed by catheter suction. A short piece of a No. 20 F. catheter on a Luer syringe is used. After all damaged brain has been removed the dura should be tightly closed.

Occasionally, in an infant, because the dura is closely adherent to the skull, a depressed bone will tear the dura, allowing the fluid to leak out and cause a hydrocele of the scalp. Opening the scalp and suturing the tissues tightly over the rent will relieve the situation until the suture lines unite and the fontanelles close.

Scalp wounds are often considered too lightly. They should be regarded as potential brain abscesses. The scalp should be shaved over a generous surrounding area, which is then thoroughly cleaned: with the patient under novocain (1 per cent) and adrenalin (5 minims to 1 ounce) anæsthesia, the ragged edges of the wound should be trimmed carefully away and the galea closed with fine catgut or interrupted silk sutures. The outer skin also is closed with interrupted silk sutures, which should be removed in 2 or 3 days. Neither through-and-through sutures nor collodion dressings should ever be used.

From Table 1 it is seen that with conditions as nearly alike as possible in 300 cases of white patients and 300 of colored patients, 83 of the former resulted in death, while only 48 of the latter terminated fatally, making the death rate in the white cases 27.6 per cent and in the negro cases 16 per cent.

It is particularly noticeable that there were 71 massive injuries among the whites as compared to 31 injuries of the same type among the negroes, while there were 48 depressed fractures among the negroes and 33 among the whites. The latter difference may be accounted for by the fact that the force of the blow was expended in only fracturing the skull in the negro cases, while a massive injury resulted in the white cases—conclusive proof in itself that the skull of the negro will withstand at least twice as much stress and strain as the skull of the white man.

Some of the valuable lessons learned from the study of this long run of cases are as follows:

1. A patient in a state of profound shock should be treated first for shock.

TABLE I.—SUMMARY OF CASES

Ages in years	White	Negro
Massive injuries		
1 to 5	5	2
5 to 10	7	2
10 to 20	14	6
20 to 30	9	9
30 to 40	9	7
40 to 50	8	3
50 to 60	8	2
60 to 90	11	0
Total cases	71	31
Total operations	14	3
Deaths	71	30
Meningeal hæmorrhage		
5 to 10	1	0
20 to 30	1	0
30 to 40	2	0
40	0	1
Total cases	4	1
Total operations	3	1
Deaths	2	0
Cured	2	1
Depressed fractures		
1 to 5	6	2
5 to 10	10	4
10 to 20	7	9
20 to 30	2	15
30 to 40	5	12
40 to 50	0	5
50 to 60	3	0
60 to 90	0	1
Total cases	33	48
Total operations	29	38
Deaths	3	10
Cured	30	38
Hypertonic cases—non-operative		
1 to 5	33	12
5 to 10	29	29
10 to 20	52	64
20 to 30	27	53
30 to 40	17	35
40 to 50	15	15
50 to 60	9	7
60 to 90	8	3
Total cases	190	218
Deaths	5	6
Cured	185	222
Deep hæmorrhages		
1 to 5	0	0
5 to 10	0	0
10 to 20	1	1
20 to 30	1	0
30 to 40	0	0
40 to 50	0	1
50 to 60	0	0
60 to 90	0	0
Total cases	2	2
Operations	2	2
Deaths	2	2

2. X-ray pictures should not be taken until the patient reacts from shock.

3. If the patient is unconscious or semi-conscious and the head injury is complicated by a fractured limb, a body cast should not be applied until the patient regains consciousness, in order to avoid pneumonia.

4. Morphine should not be given for severe headache following a head injury, for the drug depresses respiration and may disguise a dangerous meningeal hæmorrhage.

5. The patient should not be allowed up too early, or the result may be an intractable headache.

6. A normal pulse rate and blood pressure may be misleading in a case in which meningeal hæmorrhage is suspected. A dangerous hæmorrhage can come about with a blood pressure of 118 and a pulse rate of 80.

7. Care should be taken not to overlook a contrecoups hæmorrhage in an unconscious patient. The scalp wound, or fracture, may be on one side and the hæmorrhage on the opposite side.

8. The depletion of a patient whose system is already impoverished by the loss of a large amount of blood may result fatally.

9. Operation upon a patient with a fast falling blood pressure will prove fatal.

10. Great care must be taken to distinguish between the irritating stage of a large hæmorrhage and a state of alcoholic excitement. Often it is absolutely impossible to distinguish one from the other for the time being.

11. Puncture wounds of the cranium, such as wounds from ice picks and knife blades, should be explored immediately.

Though the much greater death rate of the whites might be taken to presuppose a greater vulnerability of the brain in the white race, the excess of massive injuries in the whites makes it clear that "the vulnerability is due to the failure of the protective function of the skull." Since this failure of the protective function brings with it gross functional disadvantages in resistance to injury, we may assume with Trotter that "it has some deep and real significance in compensation." As he further says, it "paid the European, so to speak, to develop a type of cranium which put him at a serious physical disadvantage in contest with his primitive competitors, and even with contemporary races of today: what can have been the 'price' he got in return that prevented the transaction from being the bad bargain it so manifestly might have been, but was not?"

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EDITORIALS

SURGERY, GYNECOLOGY AND OBSTETRICS

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FEBRUARY, 1930

A RELATION BETWEEN ACUTE INFECTIONS OF THE UPPER RESPIRATORY TRACT AND INFECTIONS OF THE KIDNEY

FOR many years attention has been called periodically to the apparent frequency of pyelitis in children coming with or subsequent to acute infections of the upper respiratory tract. However, the precise relationship between these two factors and the question of whether indeed there is any relation at all has been obscure.

The organisms concerned with the throat infection are commonly various cocci while the organism which appears to be the causative agent in the kidney infection is most commonly the colon bacillus. Most painstaking work by Helmholtz and others has failed to explain the illusive relationship. Again, Rosenow and other workers following the lines which he has indicated have concerned themselves with the relation of chronic foci such as those in tooth and tonsil to infections of the urinary tract, but again the organisms concerned have commonly been widely different and the exact relationship has remained obscure. In sharp contradistinction to these facts which have defied accurate correlation, is the well known relation between acute infections of the skin and bone with acute infections of the kidney. It is a matter of common knowledge that patients with boils, carbuncles, and acute osteomyelitis occasionally develop acute infections of the kidney with the staphlococcus, which is the causative agent of the primary infection. Here the relationship is generally clear and definite and the organisms found in both lesions are the same.

For several years we have been interested in observing a group of patients, most of whom have, perhaps accidentally, been young adults of both sexes who, coincident with some acute infection of the upper respiratory tract, commonly a tonsillitis, have had the following clinical picture: At some stage during the throat infection, never at its beginning, the patient has pain varying from one of moderate intensity to one of great severity occurring in one or the other, rarely in both, renal regions. This is accompanied by definite costovertebral tenderness, occasionally by spasm of the anterior abdominal muscles, commonly by nausea, occasionally by vomiting. The fever rises sharply, often to 103 or 104 degrees. The leucocytosis which has heretofore been moderate, rises definitely, often reaching 20,000 or more. In these patients, to ordinary routine methods of examination the urine is habitually normal. However, careful examination of highly centrifuged, very fresh specimens which in the female must be obtained by catheter and in the male must be the terminal portion, will regularly show cocci in large numbers. In the overwhelming majority of

these patients, the fever persists for a few days; the tenderness, leucocytosis and cocci in the urine remain for the same period. Then all the symptoms gradually subside, the cocci disappear, and careful check-up has appeared to show that the patient had entirely recovered.

We have come to believe that this clinical picture is considerably more common than has been generally supposed, that such attacks, often relatively mild, are fairly common and that they are in fact evidence of acute renal infections, we believe of the cortical type, which go on to spontaneous recovery.

I desire to call attention to this group since I think it will bear wider study but I also wish to call attention to a group of cases which follow from this clinical picture and which seems to me may possibly throw light upon the whole question of renal infections through the blood stream in the previously undamaged kidney. A certain proportion of these cases, instead of going on to spontaneous recovery continue to show the clinical picture before suggested, except that the fever continues, the kidney can be demonstrated to be definitely enlarged, and pus in small quantities not rarely appears in the urine. At the end of two or three weeks, the process begins spontaneously to recover but commonly enough, colon bacilli will appear in the urine as the cocci are disappearing and as the pus begins to show. There is here, I think, a suggestion that the colon bacillus is more often than we have believed, a secondary invader; its rapid growth in the urine may easily be misleading since the bacilli can increase enormously during the time the urine remains within the body. In this way they will obscure the examination of the urine as made by centrifuge, smear, and stain, a method upon which we have come to rely more than upon culture. However, the possibility of overlooking cocci in the presence of an overgrowth of colon bacilli is perhaps equally as likely in culture as in smear.

As far as I know there is very little evidence of the condition of the urine in children with acute upper respiratory infections until pus is found and a pyelitis more or less acute is well established. It seems to me not impossible that the organisms involved in the upper respiratory infection may in fact be those which first invade the kidney, first reduce its vitality and make it a congenial abiding place for the more or less ubiquitous colon bacilli. The field is, I think, one which will continue in the future, as it has in the past, to repay careful study. HUGH CABOT.

HYSTERICAL LITHIASIS

TO the various types of urinary calculi which are usually described in the literature should be added a form of lithiasis, or rather pseudo-lithiasis, which is not generally recognized and which from its nature may well be termed "hysterical lithiasis." This unusual manifestation of abnormal psychological process is manifested by symptoms simulating acute renal colic. In order to complete the deception, the patient will produce a stone shortly after the colic, which to the casual observer may be mistaken for renal calculus. In addition, one patient, following the pseudo-colic, was able to demonstrate hæmaturia, which on examination proved to have its origin in a self-inflicted periurethral abrasion. Although renal colic is simulated by some patients in order to secure a desired drug, in most instances this unusual form of invalidism is assumed to obtain attention and sympathy. Two of the patients had previously passed true renal calculi and one patient had had a stone removed from her kidney, so that they had no difficulty in

simulating actual renal colic. Several patients inserted a calculus into the bladder prior to roentgenographic and cystoscopic examinations. One patient carried a small bag filled with pebbles, which she surreptitiously placed in the lumbar area at the time of roentgenographic exposure. That it is easy to confuse the symptoms accompanying this form of psychoneurosis with those of true lithiasis is shown by the fact that in none of the cases had the condition been recognized at first and in each instance several physicians had treated the patient in good faith for actual lithiasis.

As a rule the stones which are claimed to have been passed can be recognized as foreign material by anyone who has previously observed renal calculi. They frequently consist of small, round pebbles, and in order to keep up the semblance of veracity the patient usually will select the same type. In several instances the stones selected were irregular and glistening. One patient presented pieces of chalk, and another bits of plaster which were dug out of the wall with the finger nail, and when crumbled resembled somewhat a soft phosphatic stone. On the other hand, urinary calculi are sometimes observed which have such a bizarre appearance that their origin may be doubtful. If there is any doubt as to the nature of the stone a chemical analysis will, of course, identify it.

Although the deception will be indignantly denied by most patients when first informed of the situation, the cure will usually be miraculous. Several patients, however, were known to continue their stony career. One patient claimed to have passed over 200 stones at regular intervals. The possibility of pseudo-lithiasis should be considered with every case of chronic stone-forming kidney and an analysis should be made of the stones to determine their organic origin.

W. F. Braasch.

MASTER SURGEONS OF AMERICA

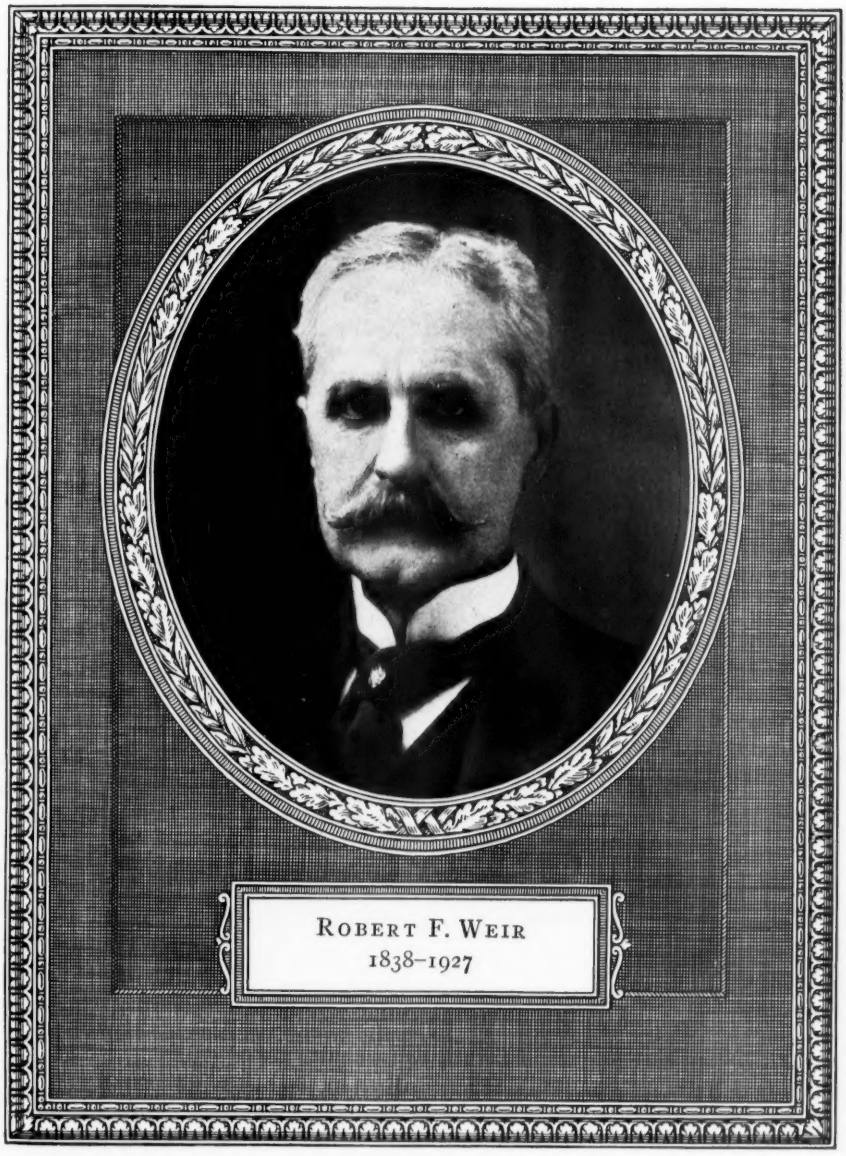
ROBERT F. WEIR

FOR a surgeon, the year 1838 was a good time to be born. Within the years of Dr. Weir's lifetime, surgery made most astonishing and important advancement, and during this period Dr. Weir witnessed the surgery of three American wars, and he himself achieved much. To live to be ninety years old is of itself some achievement. It is fortunate for the historian that the subject of this sketch left some private personal reminiscences of his early life which, through the kindness of his only child and daughter, Mrs. La Montagne of New York City, we are permitted to record:

I had graduated, the youngest in my class, from the just established New York Academy (later the College of the City of New York) and had started as a clerk with my father, who was an apothecary in Grand Street. Dr. H. B. Sands, who later achieved great eminence, was also the son of an apothecary. During the two or three years I was acting as a clerk, I rose from taking down and putting up the store shutters to become quite expert in the manufacture of tinctures, etc., and acquired, thanks to a pleasing and diligent perusal of Wood and Bach's *Dispensatory*, quite a fair knowledge of medicines and their actions on the human body. Perhaps this training inclined me to the practice of medicine, but I have always been convinced that two incidents determined my career. The first was the experience I obtained from the painful ingrowing toe nail of my big toe. It plagued me so badly for several months until my father sent me one Saturday to the office of Dr. James R. Wood, whom I had frequently seen in our store and who was generally known by all the neighborhood as "little Dr. Jimmy Wood." His office was at the corner of East Broadway and Market Street (and they were fashionable streets then). There he held once a week a sort of clinic for his numerous students. Thither I went in due time, and was ushered into his sanctum. He examined my stripped toe and while explaining to the embryo medicos the nature of the trouble, slyly took up a pair of pincers, and quickly placing one jaw of this under my nail, clamped the upper jaw to and pulled the nail out. I gave a jump and a wild yell, but it didn't hurt so much as I thought it would, since the nail had been considerably loosened by the prolonged inflammation and suppuration. I went home relieved, and, telling my father of it, I said: "I'd like to be able to do like that." (This impression was augmented when a few months later, his father sustained a Pott's fracture and was treated by the same Dr. Wood.) The next day I announced my firm determination to become a surgeon.

How interesting it would be if other great surgeons had left biographical notes of the early mainsprings of their careers!

Dr. Weir entered the office of Dr. Gurdon Buck (of Buck's extension fame) as pupil and assistant and became a student at the College of Physicians and Sur-



ROBERT F. WEIR
1838–1927

geons. "Dr. Buck was a large man with a face somewhat German in aspect, slow in action and in speech, but having a thoughtful mind and fertile in surgical expedients." Dr. Weir remained with Dr. Buck three years. He tells a story of how one day, in giving ether for him, he diligently palpated the right eyeball of the patient (the method then in vogue to tell if the patient was under the anæsthetic), only to find after embarrassing cries and struggles of the patient, that he was the possessor of a glass eye! Later Dr. Weir acted as Dr. Buck's first assistant when he put on his first Buck's extension at the New York Hospital.

Dr. Weir tells of an amusing incident at the graduating exercises of his college. The seats of the auditorium had recently received a heavy coat of varnish—too recently to become thoroughly dry. When the audience started to arise at the conclusion of the exercises, they found that they were almost glued to their seats. Dr. John C. Dalton who gave the address remarked that the students followed his words with fixed attention. Dr. Weir offered as his graduating thesis, "Hernia Cerebri," for which he received a prize of fifty dollars.

In 1856 Dr. Weir became an interne, or "junior walker" as it was then termed, at the New York Hospital which was started by Dr. Bard away back in 1769.

It is interesting to read Dr. Weir's account of the method of procedure at the New York Hospital for what were considered major operations at the time when he was house surgeon (about 1858):

> The senior walker was expected to lay out the instruments: they had been resting on a velvet-lined shelf or were bedded in velvet-lined slats in an adjoining closet. He would make inquiries of the nurse, who was at other times a ward nurse, about the sponges, which, having been washed out from a previous operation, had been kept in a wooden pail of fresh water. Fine, beautiful and soft looked they when taken from the pail out of the water and placed in a basin for the nurse or one of the walkers to hand to the surgeon during the operation. Sometimes the surgeons washed their hands previously—sometimes not. Fingers laden with germs in large quantities on them or under the nails were stuck into the wounds we made and we further introduced (alas, all this was unconsciously done) infectious and often fatal germs by the brilliant and apparently clean instruments we employed. After we had done all this we tied blood vessels with strings with long ends, so that we might pull them out when they loosened themselves from the tied arteries. Furthermore, we dressed our wounds with wax cerates kept in jars open to germ-laden dust and smeared over lint with foul spatulas."

In 1861, Dr. Weir, desiring to enter the regular U. S. Army Corps, went up for the required examination. Concerning this, here are Dr. Weir's own words: "During the examination I thought my chance of passing was gone when the chairman of the board asked me in sharp tones to give the treatment for pneumonia. But, he said, 'you have not mentioned blood-letting. Wouldn't you employ it?' 'No,' I replied, 'I wouldn't.' 'But, Dr. Weir, if I had pneumonia, wouldn't you bleed me?' 'No,' I firmly replied, 'that day has gone by.' 'Then I wouldn't like to have you for my doctor,' retorted he. But his bark was worse than his bite, for I passed."

On the way to Frederick, Maryland, Dr. Weir was received by Lincoln at the White House, and was again presented to him when Lincoln came to Frederick.

The hospital at Frederick of which Dr. Weir was chief was in proximity to the battlefields of the Shenandoah, South Mountain, Antietam, and Gettysburg. He saw it rise to a capacity of 3,000 patients and his assistants increased in number to 25 exclusive of the "medical cadets." From 1862 to 1865 Dr. Weir had charge of the "United States of America General Hospital" at Frederick, Maryland, one of the Government's largest hospitals, and for his services was publicly thanked in the general orders of the Surgeon General's office. It is interesting to read in a recent personal communication from Dr. W. W. Keen:

> At the battle of Antietam I was in charge of the Ascension General Hospital in Washington. I was ordered to Frederick, Maryland, in the neighborhood of Antietam and was Weir's first assistant in the administration of the hospital there, more especially in the supervision of all the capital operations. Either he or I had to approve of them before they were done because many of those who had patriotically volunteered were without a fundamental knowledge of surgery.
>
> Weir was a capital operator, careful, judicious and resourceful. I have hardly known a better one. He also ingeniously suggested that in certain cases where the appendix had to be removed, the stump should be sewed first in the abdominal wall, leaving the aperture of the stump in the abdominal wall. By this means we would be able to wash out the whole of the great bowel at any time and to any extent, and when the necessity ceased, the small opening of the appendix in the abdominal wall was closed. He was indeed a Master Surgeon."

In the *Transactions of the American Surgical Association* for the year 1927 appeared an obituary notice written by Dr. C. L. Gibson of New York City:

> Dr. Weir was president of the American Surgical Association 1900–1903. He had not been active a number of years before his death and had survived a brilliant group of surgeons who have left their impress on American surgery—notably Sands, Markoe, Thomas Ball, McBurney, McCosh, Hartley and Gerster. His Civil War record was marked by extraordinary achievement. He was always an indefatigable worker in research and was always in the front rank of progress: a distinguished leader, and many of the brilliant members of the American Surgical Association owe much of their development to his personal example and interest.
>
> His greatest activity was in an epoch when pioneer work was being done along many lines of surgery, and he had his share of success. He was one of the early workers in brain surgery. He made a great many contributions to surgical literature.
>
> Dr. Weir was a handsome man, of striking personality, and his fine character invited much affection and loyalty, especially of his younger associates. He was also a great traveler and his reminiscences and experiences are most interesting and valuable.

Dr. M. Allen Starr, who was intimately associated with Dr. Weir for so many years in college work, addressed the New York Academy in 1927 as follows:

> As Professor of Surgery in the College of Physicians and Surgeons from 1873 to 1903, he taught many of the men of this country now distinguished, who came from all parts to attend his clinics and to watch his operations, and he imbued them with enthusiasm for their profession, as well as sound knowledge of its principles. His wide experience gained chiefly in the Civil War in which he served as surgeon in charge of the hospital

at Frederick, Maryland; his ample knowledge of surgery gained by familiarity with home and foreign literature; his skill in the varied lines of operative work; all combined to place him in the front rank of the surgeons of his time. And his genial nature, delightful personal manner, wide interest in art and letters and life outside his profession added to the esteem and affection with which he was held by his friends. He visited Europe many times and also went to Japan and China. . .

As attending surgeon in the New York Hospital from 1876 to 1903, he was an indefatigable worker without regard for financial return, for at that period the hospital was given over to charity patients and *private wards were not opened* (italics mine). This industry is evident by the very long list of his publications in the medical press during these years, more than a hundred being mentioned in the *History of the College of Physicians and Surgeons* published in 1900. During this period the introduction of Lister's methods of antiseptic, and later aseptic, surgery was the subject of the greatest interest, and Professor Weir was among the first to adopt, urge, and teach modern methods which eventually revolutionized surgical procedure. While his chief work was in abdominal surgery, he was the first in this country to operate for a brain tumor, under the direction of Sequin, and the success of that operation led him to make many contributions to the surgery of the head and brain. There is hardly any field of surgery in which his published articles do not increase knowledge. And his diagnostic wisdom and good judgment combined with his skill in operative procedure added to his reputation and in many lines made him the chief authority of his time.

He was elected president of the American Surgical Association in 1900, member of the International Surgical Association, president of the New York Surgical Society, of the Practitioners' Society, of the New York Academy of Medicine, and of the Greater New York Medical Society. In 1895 he was made a corresponding member of the Société de Chirurgie de Paris, and in 1905 an honorary fellow of the Royal College of Surgeons of England. Of this latter appointment it is interesting to note that Dr. Weir, Dr. Keen, and the Prince of Wales received this honor at the same time. It was the first occasion that an honorary degree had been bestowed by that body.

During his extensive practice in New York City, he had associated with him as partners Dr. Robert Abbe, Dr. Gibson and Dr. Ellsworth Eliot, all whom became eminent. Dr. Eliot, in a personal communication, writes: "Dr. Weir never developed a hobby although he tried hard on the tennis court and whist table. By his internes he was affectionately called 'Bobbie' and of this he was aware."

A few months after the organization of the American College of Surgeons in Washington, D. C., Monday evening, May 5, 1913, Dr. Weir at the first convocation, held in Chicago, November 13, 1913, was made an Honorary Fellow. The only other surgeons so honored were Sir Rickman J. Godlee, London; William Stewart Halsted, Baltimore; William Williams Keen, Philadelphia, and John Collins Warren, Boston.

Many honors were bestowed upon Dr. Weir, he had appointments on the staffs of many hospitals, and belonged to the principal medical societies of his time.

JOHN HAMMOND BRADSHAW.

THE SURGEON'S LIBRARY

OLD MASTERPIECES IN SURGERY

ALFRED BROWN, M.D., F.A.C.S., Omaha, Nebraska

THE PHARMACEUTICAL AND SURGICAL PHILONIUM OF VALESCO DE TARANTA

IN Europe from the beginning of the Middle Ages instruction in and practice of the sciences passed gradually into the hands of the clergy. Naturally of all the sciences surgery and secondarily medicine suffered the most. The dictum that the Church abhors blood prevailed, and such surgery as there was was performed by itinerant charlatans and mountebanks. The literature of medicine save for the little that was preserved by the Benedictines was practically lost. The hospitals and schools established by the Romans became little more than homes or resting places for the poor and indigent. Then a change for the better began. Constantine, Roger, Roland and the four masters began their work at Salerno. The former translated the works of the ancients and re-established the result of their labors as a new literature in Europe. Roger and Roland wrote individual works and with the swing of medical education and instruction to the north, Montpellier became the outstanding school and Guy de Chauliac and John Arderne wrote their individual works in surgery. But still there was no general compendium or textbook so to speak and the literature was hard to find and when found only fragmental.

Valesca de Taranta was a Portuguese who had studied in Lisbon and was attracted to Montpellier where he continued to study. He says that he began to practice medicine in 1382 and as he precedes his discussions of diseases throughout his book by a short description of the anatomy of the part involved, one may gather that he had taken advantage of the fact that from 1376 on, a dissection of the body of a criminal was permitted annually at the school of Montpellier. So this school, even though under the management of the unmarried clergy who composed its faculty, was rising out of the fog of the dark ages and endeavoring to expand to a more modern conception of science. Valesca continued to practice at Montpellier and became one of its pre-eminent men and probably one of the professors at the school, for he was appointed later Archiater of King Charles VI of France. During the latter part of the fourteenth century, he began to write and published his first book *Tractatus Epidemialis* in 1401. Nothing more came from his pen until he had been thirty-six years in practice, when he finished his great work *The Philonium*. One of the reasons he wrote the book was to furnish to the profession a complete practice of medicine, because he noted and deplored the paucity of books at this time. Daremberg states that in the preface to an early edition he says "where will one find the books of Hermes, of Rufus, of Andromachus, of Paul, of Oribasius?" He then goes on to explain that it is his intention to write a complete treatise which will gather all the information contained in these books in one volume, naively adding that it would be free from all errors, and then enters into a description of the superstitions of which the *Philonium* is full. He appears to have been greatly impressed with the importance from a superstitious standpoint of the number seven, a belief prevalent at the time. He calls attention to the fact that there are seven cardinal sins, seven spirits, seven petitions in the Pater Noster, seven days in the week, seven planets, and many other important sevens. Consequently he divides the *Philonium* into seven books which treat of diseases of the human body in an orderly sequence, from the head to the feet.

At a later period, the exact date of which is unknown, he wrote his smaller treatise, *The Surgical Philonium concerning the method of cure of external affections*. In this he discards the head to foot method of division and considers surgical affections from the standpoint of pathology and symptomatology beginning with abscess, phlegmon, erysipelas, carbuncle, etc., and ending with a thirty-first chapter which describes hæmorrhage from wounds.

Valesca de Taranta was one of the first of the physicians of the late middle ages to attempt to gather the material of the ancients in an accessible form and he succeeded fairly well. His knowledge of the ancient literature was considerable for his quotations from nearly all the early authors of importance are multitudinous. He includes both the ancient Greeks and the Arabians and does not neglect the writers just previous to his own time. It is not at all surprising, therefore, that when printing came into vogue his work should become popular. It was first printed in 1490, including both the medical and surgical parts, preceded by an introduction by Joannes de Tornamira, Chancellor of Montpellier. During the sixteenth century no less than ten editions were necessary to supply the demand. By the time the eighteenth century was well under way, however, later books had become more popular and Taranta's *Philonium* appeared for its last printing in 1714.

REVIEWS OF NEW BOOKS

THE book entitled *Robert Jones Birthday Volume*[1] is a collection of surgical essays by various authors. The preface by Sir Berkeley Moynihan is a masterpiece. These papers were written by the closest personal and professional friends of Sir Robert Jones. It is an expression of the high regard which these men maintain toward their friend, colleague, and, in many cases, their teacher. Each paper was written by a man who writes with authority on his subject. The papers are clearly written, well illustrated, and the subjects well chosen. The volume is a worthy tribute to the great Sir Robert Jones.

The chapter on the history of orthopedic surgery is interesting. Osgood gives a summary of his opinion on the association of intestinal stasis and spinal and sacro-iliac arthritis. Putti describes two cases of tumor of the femur. His operative procedure is ingenious and his points in diagnosis and treatment of bone tumors are valuable. Jansen's discussion of the dissociation of bone growth is very good.

Hey Groves' paper on the treatment of congenital dislocation of the hip discusses the open operative reduction. His anatomical considerations are very good. Allison discusses open operations for congenital dislocation of the hip. Elmslie writes on fibrocystic diseases of the bones.

Holland gives a complete exposition of the accessory bones of the foot, describing 24 conditions.

The late Clarence Starr summarizes his valuable teachings on acute infections in bone, emphasizing the points in diagnosis and the principles of treatment. Mitchell discusses spiral fractures.

Platt treats the subject of nerve disturbances in the elbow region. Fairbank describes 8 types of cervical coxa vara. Aitken discusses curvature of the spine. Bristow's contribution is on the subject of cysts of the semilunar cartilages of the knee. Smith discusses sidelights on knee joint surgery.

McMurray's paper on the diagnosis of internal derangements of the knee is highly authoritative. Bankart discusses dislocations of the shoulder joint, enumerating 7 complications. Calve's classical description of osteochondritis vertebrale infantile is in French. Wheeler describes bone grafting in Pott's disease. Girdlestone discusses arthrodesis of the hip. Evans writes on astragalectomy. Dunn's discussion on arthrodesis of the tarsus is very valuable. Trethowan discusses fracture dislocation of the ankle, and Lynn-Thomas contributes "an Appreciation." P. L.

A COMPACT monograph[2] on the physiology, technique of measurement, and practical importance of venous pressure has been written by Professor Eyster. This is a new and worthy addition to bedside study. It is important enough to warrant widespread attention, and should be read by all internists.

It seems proved that measurement of the venous pressure is an indirect but specific determination of the functional status of the heart, and as such, it is an aid in replacing clinical opinion by objective measurement. Certainly the value of arterial pressure measurement is so great that it is hard to imagine doing without it. Doctor Eyster's instrument for measuring venous pressure at the bedside is shown and explained, and the technique of its use is fully given. His observations suggest that venous pressure measurement may be of greater immediate importance in heart failure than arterial blood pressure. But in addition to this practical aspect, which is well presented, he makes an exact analysis of circulatory dynamics in heart failure that is fascinating to anyone interested in this most important and common problem. PAUL STARR.

THE fourth volume of the *Oxford Monographs on Diagnosis and Treatment*[3] concerns a field in which there is very widespread interest, i.e., diseases of the thyroid. It is written, as are the other volumes in this series, by men who have personally contributed greatly to the advancement of knowledge in the field covered. The volume is introduced by an interesting historical review of earlier clinical observations. The anatomy and functions of the gland, thyroxin, a classification of thyroid disorders, and a consideration of the use of the metabolic rate are presented in the next chapter. Then follows a general discussion of methods of treatment with an illuminating account of surgical sequelæ. The remainder of the work covers colloid goiter, exophthalmic goiter, adenomatous goiter and hypothyroid states.

In general, this is not a personal critique but an impartial presentation of commonly held views. The material is supported by many references throughout the discussion and a considerable list of titles follows every chapter. Several illustrative cases accompany each clinical problem presented. This volume certainly gives a broad and, at the same time, thorough view of modern knowledge of thyroid disease. PAUL STARR.

TO one who has spent approximately a quarter of a century in the fascination of similar work, this small volume on *The Treatment of Fractures*[4] betrays expressions of disappointment and wails of complaint against the non-recognition of the value

[1] THE ROBERT JONES BIRTHDAY VOLUME; A COLLECTION OF SURGICAL ESSAYS. By Various Authors. New York and London: Oxford University Press, 1928.

[2] THE CLINICAL ASPECTS OF VENOUS PRESSURE. By J. A. E. Eyster, B.Sc., M.D. New York: The Macmillan Company, 1929.

[3] THE DIAGNOSIS AND TREATMENT OF DISEASES OF THE THYROID. By James H. Means, M.D., and Edward P. Richardson, M.D. New York and London: Oxford University Press, 1929.

[4] THE TREATMENT OF FRACTURES. By Lorenz Boehler, M.D. Authorized English translation by M. E. Steinberg, M.S., M.D. Vienna: Wilhelm Maudrich, 1929.

of preparedness and efficient care in the treatment of fractures. One wonders why in the analysis of surgical values the study and treatment of fractures are belittled. Certainly the gross mortality, the functional and economic loss, and the unhappy influence of these lesions on human life are as great as the other more frequently discussed major causes of death.

This book bears the stamp of individuality. It is divided into two parts: the first covers general remarks on the treatment of fractures; the second covers specific fractures. The discussion on pseudoarthrosis is particularly good. Open operation on recent fracture is frowned upon. For the average reader there is considerable imbalance in the space allotted to the various bones, skull fracture, for example, having a scant two pages.

The author's hobbies are well expounded, namely, local anæsthesia for reduction, almost constant use of skeletal traction, zinc gelatin dressing and the application of unpadded plaster-of-Paris dressings to fractured limbs.

On the whole the translation of the second part is better than the first part. The value of the book lies principally in the illustrations, the expression of one man's experience, and in its use as reference for anyone who has watched the author work.

KELLOGG SPEED.

THE general scheme of the book on *Diseases of the Larynx*[1] is that of most texts on diseases of the throat. However, it has the added advantage of including diseases of the œsophagus and large bronchi. Endoscopy in its various phases is dealt with exceedingly well for a small text. The illustrations are well done and the latest work on surgery of the larynx is well delineated. The conciseness of the text recommends it for the student.

JOHN F. DELPH.

[1] DISEASES OF THE LARYNX INCLUDING THOSE OF THE TRACHEA, LARGE BRONCHI AND ŒSOPHAGUS. By Harold Farwell, M.B. (Lond.), F.R.C.S. (Eng.). New York and London: Oxford University Press, 1929.

THE third edition of *A Manual of Proctology*[2] by T. Chittenden Hill is practically the same as the previous one. Little new material is added. In the chapter on ulcerative colitis the work of Bargen and Logan is mentioned but the author does not give his experiences with this form of treatment.

The injection method of treatment of internal hæmorrhoids is fully described, the different solutions discussed with preference given to the 5 to 10 per cent solution of quinine and urea hydrochloride as originated by Tirrell in 1916. It is plainly pointed out that this form of treatment is unsuitable for external hæmorrhoids and the excessively hypertrophied, fibrous, internal hæmorrhoid.

The chapter on cancer of the rectum has been revised. The selection of suitable cases for operation together with the pre-operative and postoperative treatment is fully discussed. The operation of choice is the one developed by Jones, which is described in all its details and accompanied by numerous illustrations.

Every subject in the field of proctology is treated in a clear and condensed form, free from many unnecessary details. It is unquestionably a very valuable book in teaching the subject of proctology.

C. J. DE BERE.

[2] A MANUAL OF PROCTOLOGY. By T. Chittenden Hill, Ph.B., M.D., F.A.C.S. Philadelphia: Lea & Febiger, 1929.

CORRESPONDENCE

A GENERAL CONSIDERATION OF CÆSAREAN SECTION

To the Editor: In the June, 1929, issue of Surgery, Gynecology and Obstetrics, in an article entitled "A General Consideration of Cæsarean Section," I made the statement that the proportion of abdominal deliveries to vaginal deliveries at Jefferson Hospital was 1 to 6. These figures were quoted from a source which I had every reason to believe accurate and reliable. My attention has since been called to the fact that they are entirely incorrect, and that the actual incidence of cæsarean section at Jefferson Hospital, including all services, is only 2.8 per cent.

I would ask that you publish this letter in your correspondence columns, in order that the injustice done, unwittingly, to this excellent institution may, as far as possible, be rectified. C. JEFF MILLER.